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AUTOMATIC COOKING MACHINE

MOHAMAD NAZREEN BIN IBRAHIM

A thesis submitted in fulfillment of the
requirements for the award of degree of
Bachelor of Electrical Engineering (Electric-Electronic)

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ABSTRACT

Cooking is becoming a challenging task nowadays especially to those who are having a hectic and busy schedule. A lot of time is spent in preparing ingredients, cooking itself and cleaning. With the advancement in technology these conditions can be overcome with an automatic cooking machine. An automatic cooking machine is a system that combines several basic cooking equipment to help human in cooking activities. Basic automatic cooking machine contains of several module such as heating, feeding, stirring, cleaning and fire control module. All cooking sequences are centered at a station. The automatic cooking machine designed in this project able to cook basic dishes just by the press of a single button on it. It has a timing control to control all the cooking process inside this system. A motor driver is used to control the stepper motor for the feeding compartment where all the ingredients are placed. An Arduino board is used as a microcontroller that will control the hardware that consists of several cooking equipment. The design will help in cooking activity as well as saving a lot of time and energy of the user.

ABSTRAK

Memasak merupakan satu aktivit yang sangat mencabar terutamanya kepada mereka yang mempunyai jadual masa yang sibuk dan padat. Banyak masa dihabiskan dalam menyediakan satu hidangan bermula dari menyediakan bahan-bahan memasak, proses memasak dan juga kerja-kerja pembersihan alatan memasak. Dengan kemajuan Teknologi pada hari ini, keadaan ini dapat diatasi dengan terhasilnya idea mewujudkan satu mesin memasak secara automatik. Mesin memasak secara automatic ini terdiri daripada gabungan beberapa peralatan asas memasak yang dapat membantu manusia dalam menyediakan hidangan masakan mereka. Pada amnya mesin memasak secara automatic ini mempunyai beberapa modul memasak seperti pemanasan, pengeluaran bahan-bahan, pengacau, pembersihan dan modul pengawal kebakaran. Kesemua modul memasak ini akan tertumpu kepada satu stesen sahaja. Mesin memasak secara automatic yang direka khas untuk projek ini akan dapat membantu pengguna dalam menyediakan satu hidangan asas dimana pengguna hanya perlu menekan satu butang khas yang terdapat pada mesin ini. Mesin ini juga mempunyai alat pengawal masa yang bertujuan mengawal tempoh masa bagi setiap process memasak. Pemacu motor diperlukan untuk mengawal motor pelangkah dalam yang terletak berhampiran kotak makanan yang mengandungi beberapa bahan-bahan memasak. Papan Arduino digunakan sebagai pengawal mikro yang akan mengawal perkakasan yang terdiri daripada beberapa peralatan memasak. Reka bentuk ini akan membantu dalam aktiviti memasak serta menjimatkan banyak masa dan tenaga pengguna.

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LIST OF SYMBOLS AND ABBREVIATIONS

DC	-	Direct Current
V	-	Voltage
A	-	Ampere
W	-	Watt
mm	-	Millimeter

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CHAPTER 1

INTRODUCTION

This chapter describes the background of the project, the problem statement of the project, objectives of the overall project and scope which are related to the development of an automatic cooking machine.

1.1 Background of Project

Nowadays, it is hard to get fresh and healthy food at food outlets. Eating out sometimes require us to survey about the cleanness and the cost of the dish that we are ordering. So cooking at home is more preferable than eating out. We can be sure that what we are eating is clean and contains enough nutrition than eating or just buying ready-made food outlets

Cooking at home need some steps starting from gettiing the raw ingredients, cooking, serving and end with the cleaning of the cooking equipment. To make all this steps easier, an automatic cooking is designed to help human in preparing their dish with the combination of all cooking process in a system. The available cooking machine nowadays is mostly for commercial use, more complex, big in size and also

sold at the highly cost. Hence, automatic cooking machine from this project is designed for home application with simpler, smaller and also at reasonable price. This automatic cooking machine will be able to serve simple Asian dishes such as soup-based dishes.

1.1 Problem Statement

Cooking requires a lot of time spent in the kitchen which sometimes make us tired. The condition is almost true, especially for working mothers and those who strongly think that fresh food prepared at home are more nutritious with less artificial additives added to it. However, time may just be the problem. Once a person focuses on her/his cooking he/she will feel tired to continue other housework. Due to these conditions, a home automatic cooking machine is proposed to overcome this problem. The cooking process will be done with just the press a button which saves a lot of time and energy.

1.2 Objectives

The main objective of this project is to design a home automatic cooking machine that is able to prepare basic Asian dishes with just the press of a single button. The proposed automatic cooking machine combines several basic cooking equipments which includes a cooking induction and feeding mechanism. The timing for each cooking sequence will be organized by a microcontroller.

1.3 Scope of Project

This project is divided into 2 main parts that involves the hardware and software part. The hardware consists of a cooking induction, feeding mechanism, stepper motor, and peristaltic pump. The software part is used to control and design the hardware part. SolidWorks is used to design the feeding part and Arduino and MicroC compiler MPLAD IDE to control the stepper motor and timing of each component in cooking process.

1.4 Summary of Work

Figure 1.1 and Figure 1.2 show the summary of work for the overall project

ACTIVITIES/ WEEK	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Research on possible project	√	√	√	√												
Literature Review					√	√	√	√	√							
Proposal									√	√	√					
Development of hardware											√	√	√	√	√	√
FYP Presentation													√	√		
Project Report														√	√	√

Figure 1.1: Gantt chart for Final Year Project (FYP) 1

ACTIVITIES/ WEEK	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Design Feeding mechanism	√	√	√	√	√	√	√											
Arduino's software							√	√	√	√								
Testing & verification							√	√	√	√								
Troubleshooting &Optimization								√	√	√	√	√	√					
Final Report (Draft)		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	
Final Seminar Presentation															√			
Final Thesis completion																√	√	√
Thesis Submission																		√

Figure 1.2: Gantt chart for Final Year Project (FYP) 2

1.5 Thesis Organization

The first chapter introduces the project in brief. This chapter describes the background of the project, the problem statement, objectives and the scope of the overall project which are related to the development of an automatic cooking machine.

The second chapter discusses on the research of previous researches that are related to the concept of automatic cooking machine. The literature review focuses on the types of food, types of food storage, and also the flow of cooking method that were used in work done in previous projects and researches.

Chapter 3 explains on the step by step methodology of the project which involves the programming of the PIC16F876A microcontroller using Microchips software to control the stepper motor and it's driver, designing the feeding mechanism using SolidWorks, and also controlling all the cooking steps using Arduino Uno board.

The results obtained from the project are presented in Chapter 4 with some discussion on the results. Lastly, Chapter 5 concludes the overall project with some recommendations for future developments of the current prototype.

CHAPTER 2

THEORY AND LITERATURE REVIEW

This chapter summarizes the researches that has be done from the related fields of the project which involves the study of various type of automatic cooking machine and the overall working system and the cooking components that involved of the related projects.

2.1 Introduction

The automatic cooking machine is the machine that helps human in cooking activities. All the cooking process is controlled by the special microcontroller. An automatic cooking machine usually designed by the combination of several cooking modules such as heating, feeding, stirring, control system, cleaning and fire control module. This entire module is centered into a station and working in the same place. The design of automatic cooking machine is different and based on what type of food produced. Based on the research on several cooking machine, the application of this machine can be divided into different types of food such as pastry maker, Asian dishes, Western dishes and automatic vending machine.

2.2 Pastry Maker

Pastry is one of the dishes that are made from flour as the main ingredients. This type of dish can serve itself using an automatic cooking machine. Special automatic cooking machine was built to serve a doughnut as the output. All the process to make a doughnut is placed inside this machine.

2.2.1 Automatic Doughnut Cooking Machine

This machine was built to produce a doughnut with all the processes were conducted by a machine and designed by Louis Snyder [1]. This is one of the first an automatic cooking machine that was presented. Figure 2.1 shows the diagram of this cooking machine.

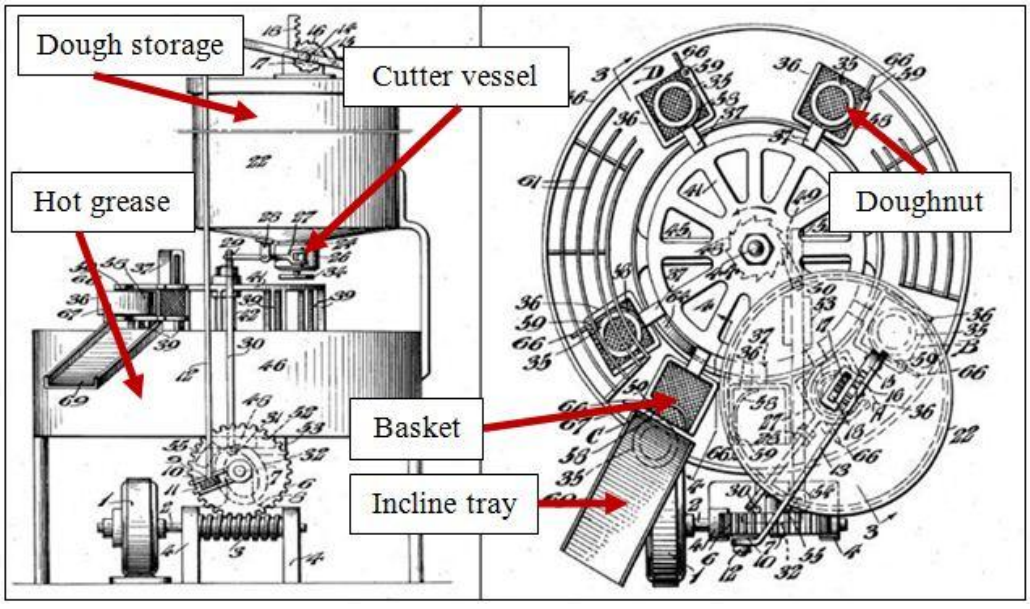


Figure 2.1: Automatic Doughnut Cooking Machine

The dough that already made to make a doughnut was sent to the specific container where the dough is stored and ready to use. The dough then compressed and cut into needed amount. This process will take place in cutter vessel. After that the dough will sent into the hot grease for cooking process.

The doughnut then placed on basket and travel under the wires until the doughnut is cooked. After the doughnut is cooked, then it is ejected to the chute or incline tray. These machines use a lot of motor to compress the dough and also to rotate the doughnut in cooking process. After the doughnut already cooked is automatically removed from the machine and ready to serve to customer.

In this machine there are several cooking components involved that are storage compartment, cutter vessel, hot grease and incline tray. Storage compartment is use to store the dough before it was sent for cooking process. Cutter vessel is located inside this machine to cut the needed amount of dough. The function of hot grease is where the doughnut is cooked and incline tray is used to place the cooked doughnut and sent to the user of this machine.

2.3 Asian Dishes

In designing an automatic cooking machine, Asian dish become one of the famous choice for the developer as the output dish for their machine. The steps in making Asian dish such as Chinese food is very complex and require a lot of time if serve it manually. Some of the automatic cooking machines are built to overcome this problem.

2.3.1 Automatic Machine For Cooking Sour-Paste, Rice, Pot Herbs Or Other Food-Stuff In Water

This automatic cooking machine is designed for cooking process that involved the use of water to cook it [2]. The main components of this machine are the burner, temperature control and timing process. This machine also use a lot of conventional control board with programming circuit to operate each mechanical movement. Figure 2.2 shows the overall system of this machine.

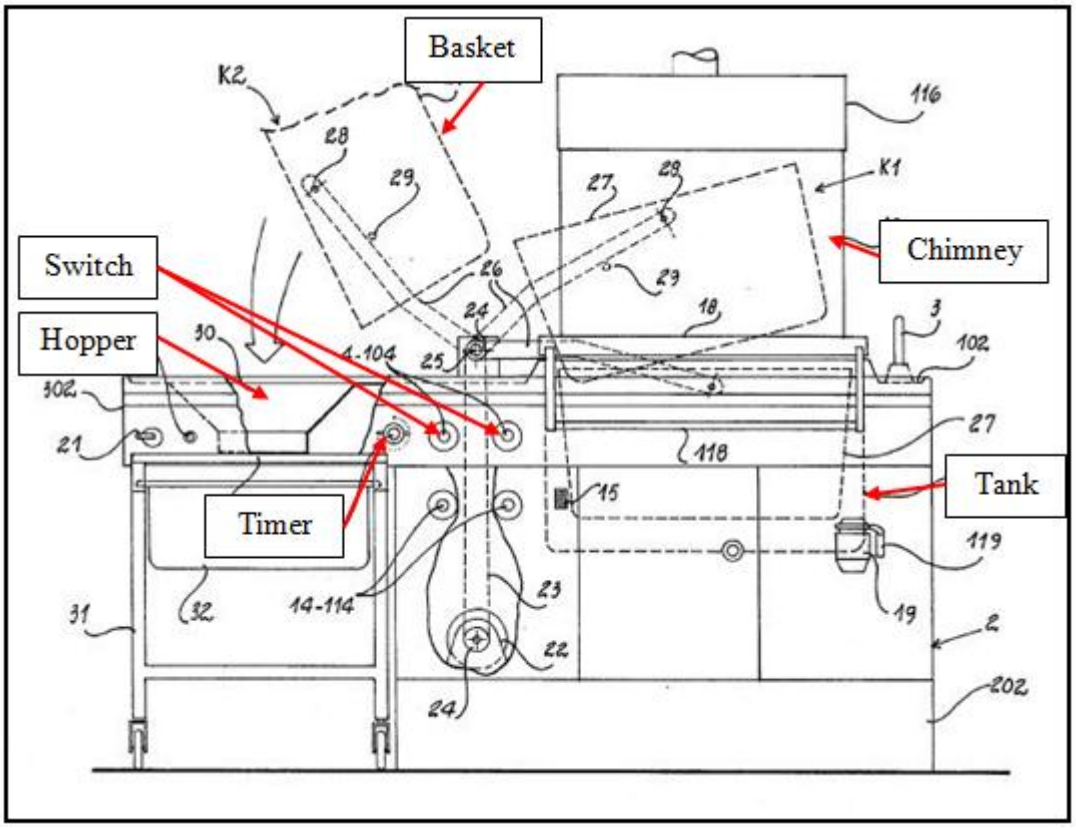


Figure 2.2: Overall system for the machine

The process begin when the tank is filled with hot water through articulated assembly. The level of water is controlled by switch that control the opening of valve that control the amount of water to be load inside the tank. Below the basket burner is located for next cooking process. One or more burner is needed to heat the basket than contained food that want to cook to make sure heating process work perfectly. Figure 2.3 shows the location of burner.

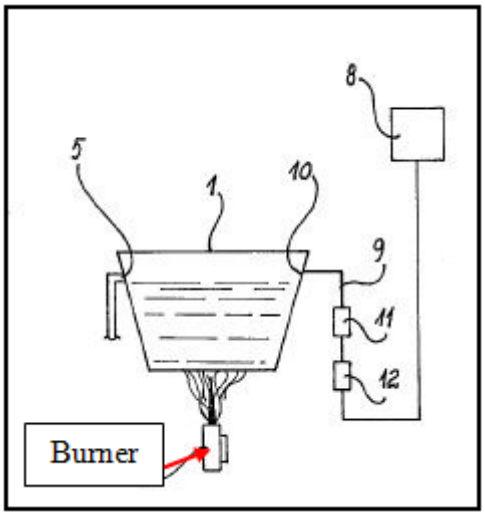


Figure 2.3: The location of burner.

To avoid any problems regarding heating process or burner process, conventional thermocouples and warning lamps are provided inside this machine that controlled with valve. To convey smoke and combustion products that are produce during heating process, special container was designed on top of the tank that called chimney. So the smoke will release to surrounding with safely.

The food inside the basket will remain inside the basket and deep into the tank that contain a hot water until it perfectly cooked. Timer control is provided to control the accurate time for the certain types of food to be cooked. After the food is cooked, basket is lift up from the tank and move from K1 to K2 (refer Figure 2.2). At the same time the burner controller will stop the heating process. The contents inside the basket will place into a hopper that located above the basin and ready to pick. The process will start from the beginning from the first step after all the food inside the basket is already placed into the basin.

The burner play an important part in this automatic cooking machine as cooking module. Valve is used to control the amount of water inside the tank. The timer is set to different type of food to check weather the food is already cook or not. This machine used chimney to control the amount of smoke that are produced during the burning process to the surrounding.

2.3.2 Computer Controlled, Fully Automatic Short-Order Wok Cooking System For Preparing Stir-Fried Chinese Food

In this machine, computer played an important role in running this an automatic cooking machine [3]. Computer will control the operation of conveyer movement, cooking process and dispensing process. Figure 2.4 shows the operation of this machine

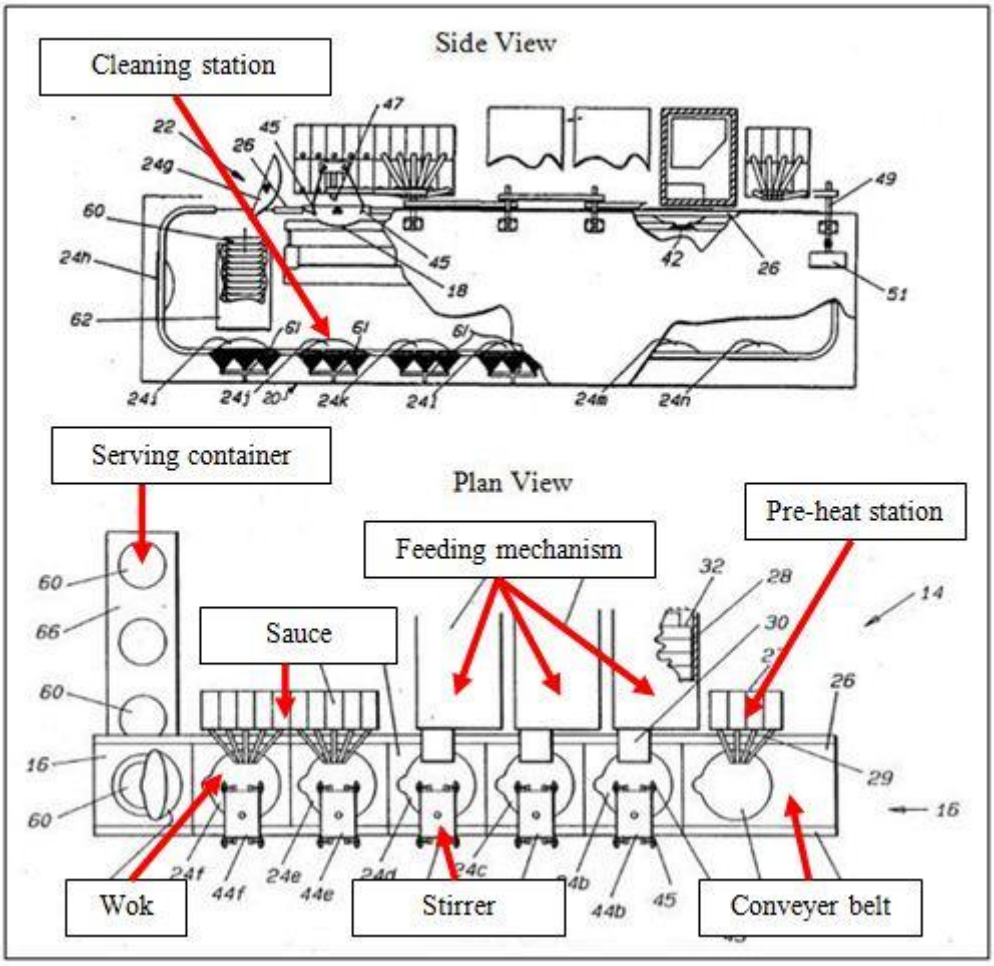


Figure 2.4: Overall machine preview

At every station, stirrer is placed to make sure all the ingredients inside the wok will cook nicely. At the end of the station, sauce is added inside the wok to give some flavor to the food that already cooked. After food is cooked, it will deliver to a serving container at delivery station.

Next the wok will enter the cleaning station where all the raw material that remains inside the wok will clean and ready to use in next cooking process. At this moment, the wok will be inverted. Hot water and soap are ejected into the wok through small pipes. Air steam and clean water is blasted to dry the wok and now the wok is ready to enter the cooking stations

The machine is divided into several stations. Conveyer is used to bring the wok into the different station. Three feeding mechanism is placed on top of the conveyer that contain three different ingredients. Stirrer also placed during the cooking process to stir the ingredients inside the wok. Additional feeding part also uses to pour sauce into the dish. This machine is almost complete when it contains the cleaning station inside the machine that will clean the used wok and start the new cooking process.

2.3.3 A New Automatic Cooking Machine for Chinese Dishes

This machine is designed to serve the Chinese food with the basic of Chinese cooking technics [4]. The idea came from the difficulties to serve Chinese food. It is take a lot of time to finish every single dish. So this automatic cooking machine will doing all cooking process automatically and can save a lot of time and energy. Figure 2.5 shows how this machine looks like.

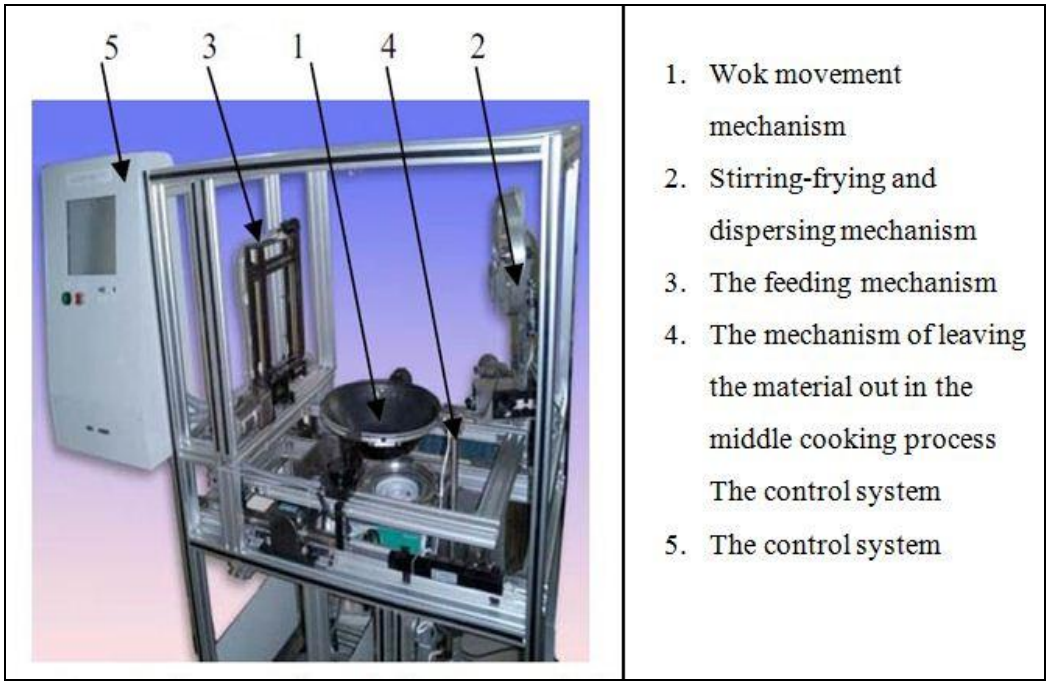


Figure 2.5: Overall preview of Chinese automatic cooking machine

At the wok mechanism, the wok will move and shaking a little bit at it starting position. This happened to ensure heat will separated evenly to the ingredient inside this wok. This mechanism works together with dispersing mechanism. Figure 2.6 shows the principle of wok mechanism.

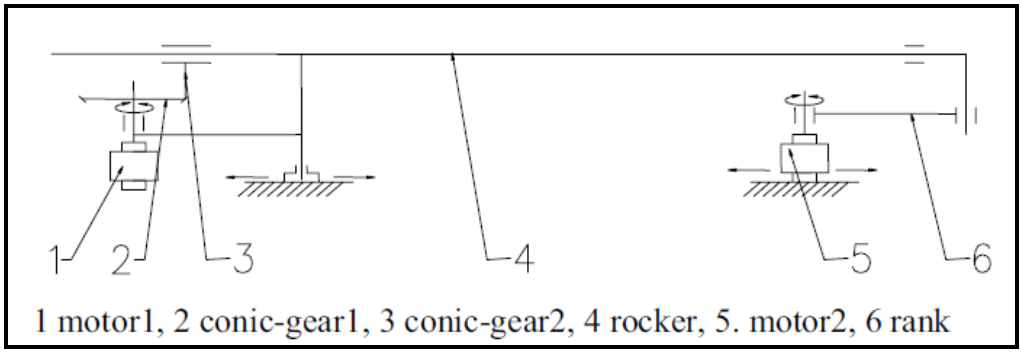


Figure 2.6: Wok mechanism

Stirring and dispersing mechanism is important in cooking process to make sure that food that we cook is not over cooked. Stirring also important to make sure the sticky ingredients heated thoroughly and also to prevent some ingredients stick inside the wok after finishing cooking process. Figure 2.7 shows the cover mechanism that used in this automatic cooking machine.

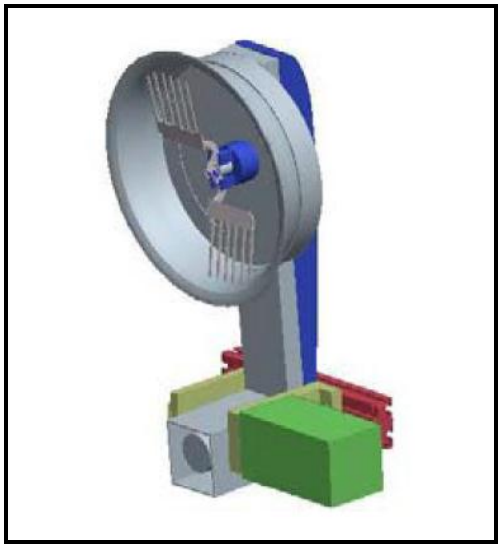


Figure 2.7: Stirring and dispersing mechanism

Next, the most important mechanism is feeding mechanism that decided how the ingredients are inserted into the wok. For this automatic cooking machine the ingredients are packed into corresponding cooking menu or dish. The ingredients are sorted according it is priority to be put inside the wok. Figure 2.8 shows all the ingredients are sealed with film and placed on the conveyer.

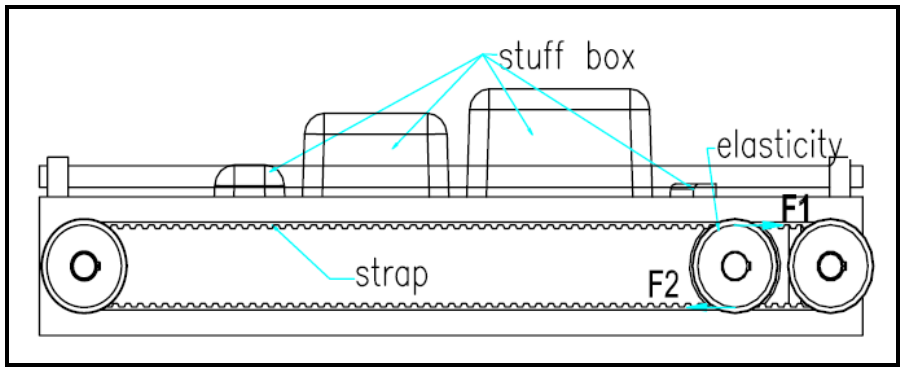


Figure 2.8: Feeding mechanism

The conveyer will rotate clockwise direction. Force F1 and F2 will rotate the elasctic axis in clockwise and the film the covered the ingredients will tear out an the ingredients will drop into the wok one by one. The timing is set by the microcontroller.

The mechanism of leaving the material in the middle process is important in serving the Chinese food. This mechanism will works together with wok mechanism. Some of the ingredients need to fry first so this mechanism needs move up and down and turn over process to achiece this mechanism.

For the control system for this machine it uses micro-processor MC56F8322 that will control all the cooking process inside this machine. The C++ programming language calling OpenGL API library functions is used to design the control system for this machine. For the fire control unit to prevent any unwanted accident during cooking process, CO concentration sensors are used for safety monitoring.

In this machine, cooking step is divided into five mains part that is wok movement mechanism, stirrer, feeding mechanism, mechanism of leaving the material out in the middle cooking process and fire control system. For the feeding part, the conveyer was use to bring all the ingredients into the wok. This machine also has a timing that controlled by microcontroller to control the all the cooking process.

2.4 Western Dishes

Beside Asian dishes, an automatic cooking machine for Western dish also presented by the designer. Western dish mostly use oil as the main medium to serve this type of dishes. French fry and barbeque are the several types of Western dish that implemented in an automatic cooking machine.

2.4.1 Automatic Food Cooking Machine for Barbeque

This automatic cooking machine is based on heating process and look like an oven to cook a food such as barbeque [5]. The main components of this machine are heating part and also the conveyer that will rotate the food inside this machine. Figure 2.9 shows the overall part of this machine.

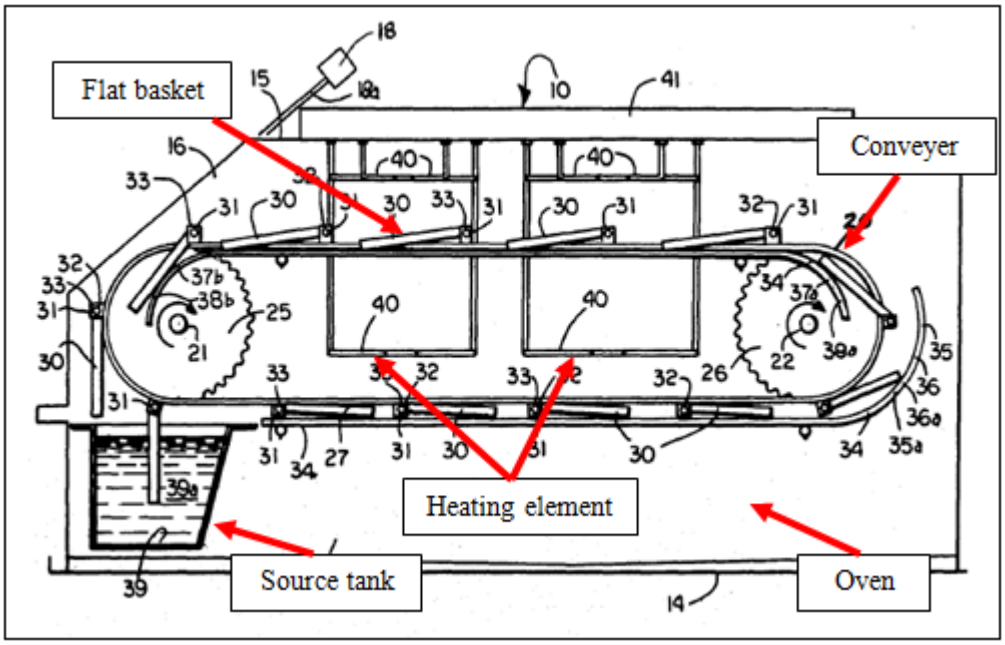


Figure 2.9: Automatic barbeque cooking machine

This machine is made of metal that will help in heating process but the outside is covered with insulator to reduce heat transfer to outer of this machine. From the Figure 2.9, we can see this machine use conveyer as a medium to rotate the food inside this machine. A pair of parallel shafts inside this machine work as gear to operate the conveyer. The shaft is connected to speed gear motor.

Along this conveyer, flat basket that is connected at the conveyer chains with rods and a pair of lug. The size of basket is depending of the size of food that wants to cook inside this machine. The foods enter from door and place on the parallel basket then pass through the heating elements and oven.

The conveyer will rotate in clockwise direction. At the bottom left of this machine there is located sauce tank to give some flavor of the food. During the cycle of conveyer, food will be dip into the sauce tank and drip the excess sauces when the basket in vertical position. This process continuous until the food is cooked.

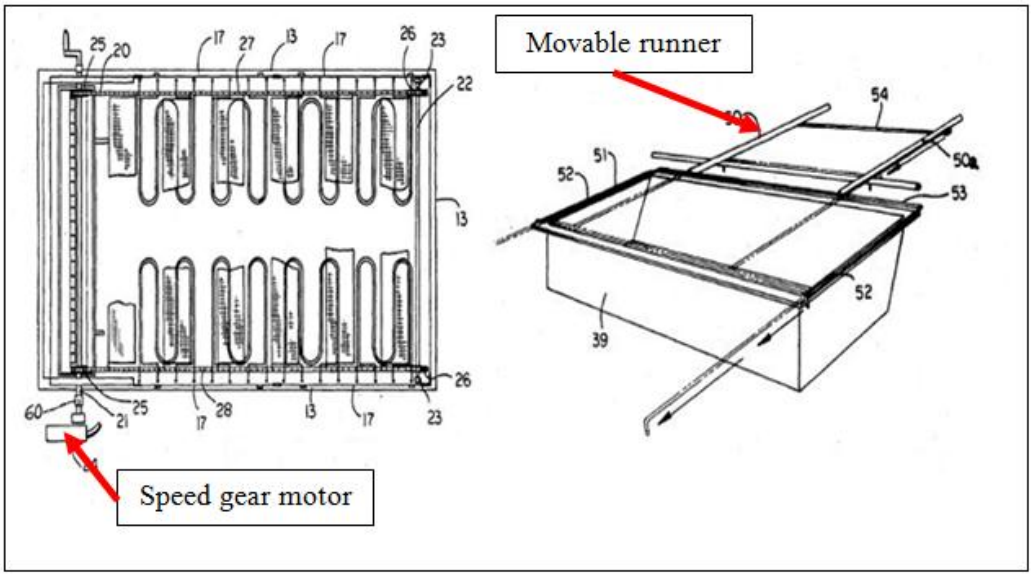


Figure 2.10: Movable runner and speed gear motor

When the food is already cooked, a pair of movable runners will put outwardly from the oven and over the sauce tank to collect the cooked food. After finish new uncooked food can be placed inside this machine by pushed back the movable runners to the center of the oven. Figure 2.10 shows the movable runner and speed gear motor.

In this machine, the feeding part is consist of conveyer that rotated by the speed gear motor. The ingredients is placed on the conveyer and sent to difference cooking station. Oven is used and placed inside this machine that function as cooking element.

2.4.2 A New French Fry Automatic Cooking Machine

This machine is improved of the previous french fry automatic cooking machine. This machine use cooking oil to fry the french fry [6]. Cooking oil is placed inside the cooking basket. All mechanical movements are controlled by microprocessor unit. Figure 2.11 shows the system of this machine.

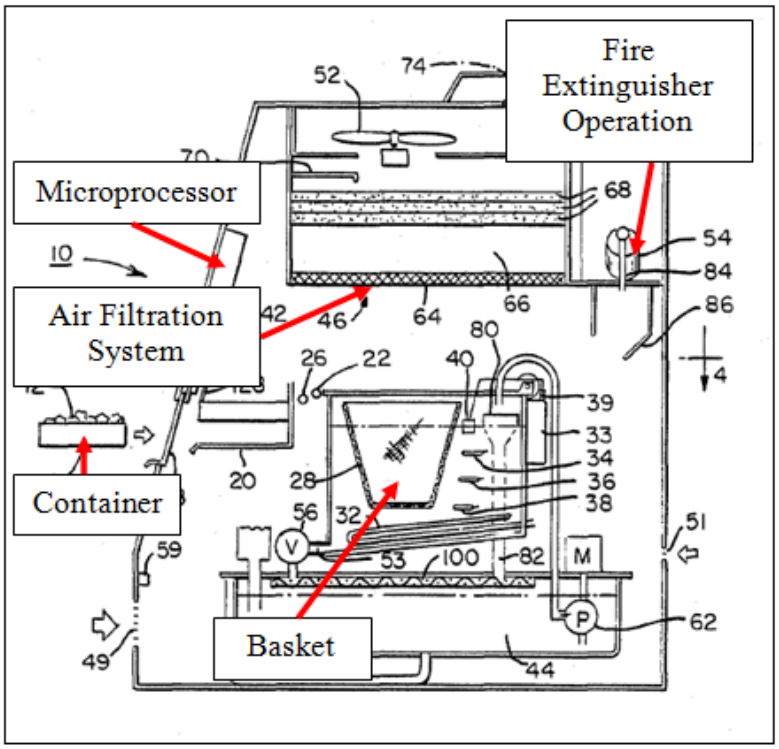


Figure 2.11: French Fry Automatic Cooking Machine

The process begins when container that contains french fry is pushed inside the machine through access window. The container then stayed at container receptacle. Then the container receptacle will rotate about receptacle rod. This process is important to make sure food inside the container will cook wisely inside the cooking basket that contains the cooking oil. After certain time, microcontroller decide that food is already cooked and lift up and rotated about basket rod to rinse the excess oil inside the food. Then the cooked food will placed inside its original place and ready to serve.

This machine is divided into several parts and system:

- The Flushing Cycle (inside microcontroller)

For this part, flushing timer is used inside microcontroller. This timer will control the on/off of the machine, time for heating process and control when the draining process should be start.

- Air Filtration System

Exhaust fan that located on top of the machine is used to suck air or heat inside the machine and sent out to surrounding during cooking process. The air is filtered first by three activated-charcoal filters before it sent to surrounding. So, smelly odor from cooking process will filter out.

- The Dumping Mechanism

Where the container that contains food is sent to container receptacle and it will deep the food into hot cooking oil.

- Fire Extinguisher Operation

It's made of glass bulb that will detect the temperature greater than 2120 F. The liquid inside this bulb will explode and discharge the fire extinguisher. Microprocessor will detect the change of fire extinguisher and it will shut down all the operation inside this cooking machine.

The feeding part is the main part of this project. The rotation of the container along the rod is controlled by microprocessor wheater the french fry is cooked or not. Specific motor is used to do the rotation process. The technique is used to cook the fries is by deeping the container inside the cooking oil. Fire extinguisher operation also build up inside this machine to control the any accident during the cooking process.

2.5 Vending for Automatic Cooking Machine

Some of the automatic cooking machine are designed with the vending machine for commersial use. The design of this types of cooking machine is more complex and bigger in size.

2.5.1 Automatic Machine For Vending Fried Food

This machine was designed by Frederic A. Sicher and friends [7]. This machine is works with the combination of vending machine that will decide whether the machine can operate or not. The output of this machine is to serve the batch of fried potatoes. Figure 2.12 shows the overal preview of this machine.

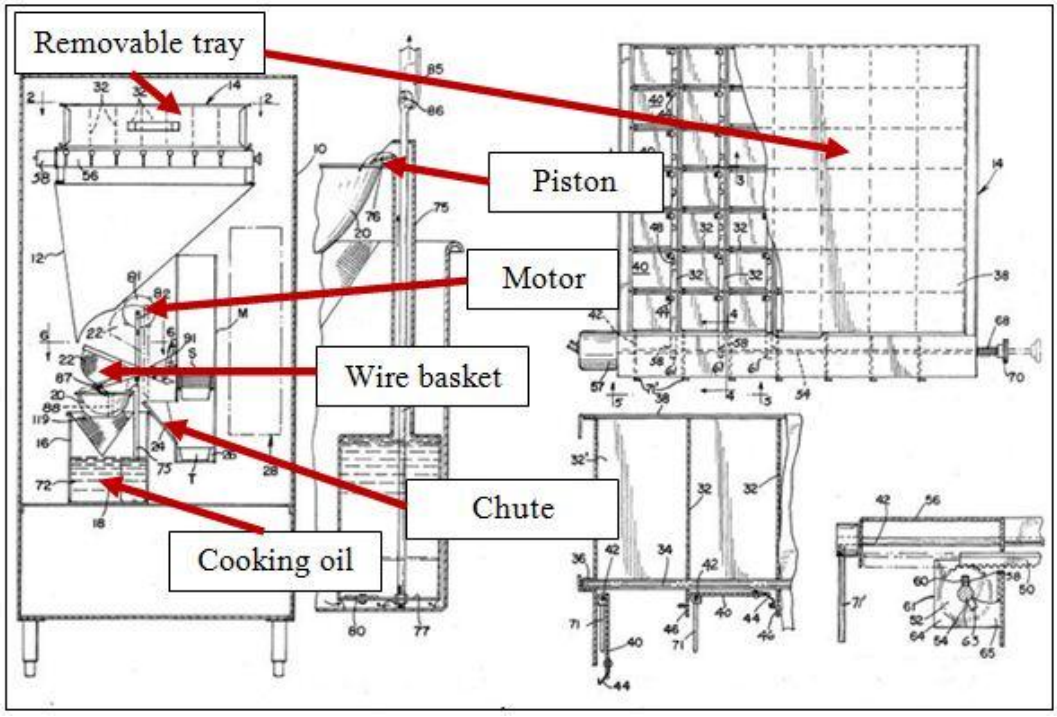


Figure 2.12: Overall preview of fried potato

Electrical operating and control circuitry were used to control the vending machine and all the mechanical systems. Timing and drive motor were used also in cooking process where the potato is deep into the cooking oil.

The machine contains of removable and replacement tray that contains the 49 rectangular bins batch of potatoes. The process begins when the one of the bin is opened. The opening of bin was controlled by release door and pivot shaft. Then the batch of potatoes will drop into potato's channel and go inside the wire basket. The wire basket will operate with another container look like a bowl that transmits the batch of potatoes into the cooking oil for frying process.

The movement of bowl is controlled by piston that connected with piston forming rod. This rod will move up and down by an operating motor. After batch of potatoes is already cooked, the motor will lift the rod up into the wire basket and sent to the chute leading to a compartment. The potatoes then will put inside the tray and ready to pick up by customer

This machine is contains of removable and replacement tray, wire basket, piston, frying station and chute. Removable and replacement tray are working as food storage to store uncooked the batch of potatoes. The wire basket and piston are work as the feeding part before it was sent to frying station. The chute is used to dry out the oil and sent the batch of fried potatoes to the user.

2.5.2 Automatic Cooking Machine for Boiled Noodles

The machine was built for boiled noodles in Japan and designed by Tatsui Tsunoda and friends [8]. This machine is built with the vending machine.

The basic component of this machine is divided into two parts, refrigeration chamber and cooking chamber. Refrigeration chamber is where the bunch of noodles was stored before sent to cooking chamber for cooking boiling process.

The bunch of noodles in the container was placed between two adjacent radial blades. The rotary shaft will rotate the drum. The rotation of drum was controlled by stepper motor below the drum. The container will placed on by one into cooking table when motor is rotated. Between the refrigeration chamber and cooking chamber, the inclined guide chamber was placed as transfer medium for the container. Figure 2.13 shows the overall this machine.

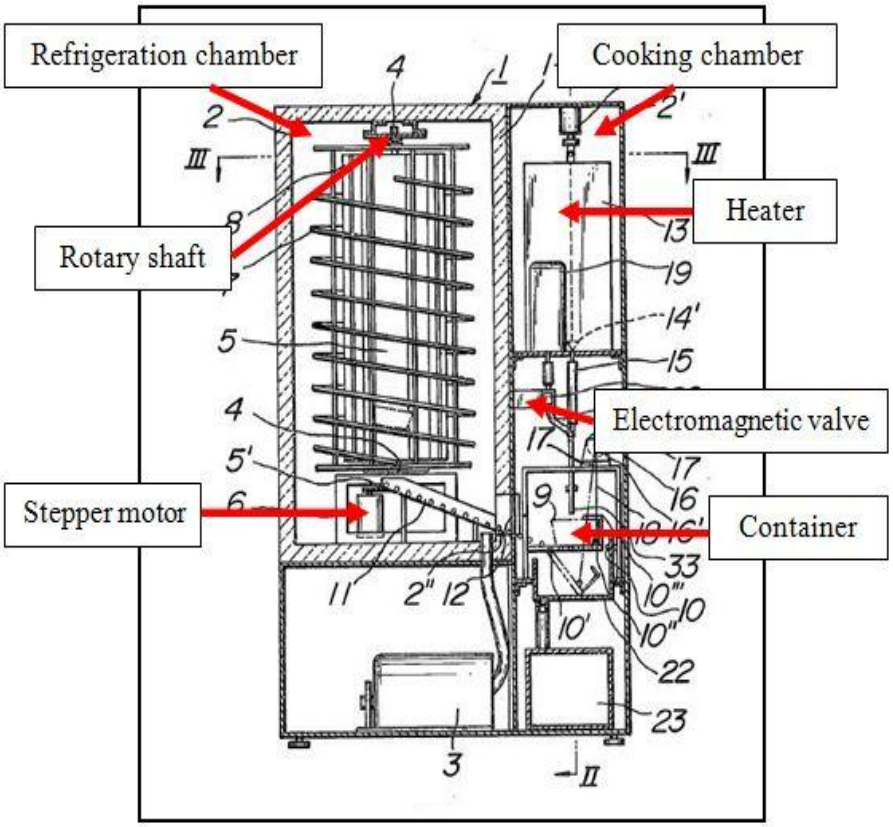


Figure 2.13: Basic design of automatic cooking machine for boiled noodles

The bunch of noodles in the container was placed between two adjacent radial blades. The rotary shaft will rotate the drum. The rotation of drum was controlled by stepper motor below the drum. The container will place on by one into cooking table when motor is rotated. Between the refrigeration chamber and cooking chamber, the inclined guide member was placed as transfer medium for the container.

After the container placed on the cooking table, the boiling noodles will start. A hot water tank which is provided with heater will supply the hot water into the container. It is placed directly above the cooking table. The amount of hot water that will use to boil the noodle was controlled by conventional timer.

Then the cooking table is rotated about its position to drain the hot water out of container to reservoir. After draining process, concentrated broth inside the broth tank is poured into the container through supply pipe. The supply pipe was provided with conventional electromagnetic valve and broth is mixed with the new hot water supply.

This machine consists of refrigeration and cooking chamber. The feeding part of this machine is consist of bunch of noodles in the container, rotary shaft, stepper motor and electromagnetic valve. Stepper motor is used to control step by step of food container into the cooking chamber while the electromagnetic valve control the flow of broth into container. To cook the noodles, heater is used as cooking components to heat the water for boiling the noodles inside the cointainer. Conventional timer is used to set the time require for noodle to cook before it sent to the user.

2.6 Advantages and Disadvantages

Based on the research of previous researches, most of the automatic cooking machines are complex and only suitable for commercial or industry use. Although all of these automatic cooking machines are complete in cooking equipments but the size will become the problem for the user to store or placed in their house. So, this problem will lead in designing a new automatic cooking machine that is simpler and affordable in price. The most important part in an automatic cooking machine is the cooking and feeding module. Both these module can be implemented in this project to make it simpler. This proposes design also suitable for home application and will reduce the time and energy of the user.

CHAPTER 3

RESEARCH METHODOLOGY

This chapter discusses about the overall project implementations and how it is done throughout two semesters. It consists of five parts, which includes the general construction, project overview, hardware design, electrical design and software development.

3.1 Basic Construction

To design an automatic cooking machine, several cooking process should be used. For this project heating and feeding elements are used to cook certain food. Cooking induction is used as heating elements while the stepper motor is used to control the feeding part. All the cooking elements are placed at retort stand that work as a holder for the cooking elements. In this project, soup-based dishes are preferred to complete the cooking process by just press a button. Acrylonitrile butadiene styrene (ABS) is a material used for feeding part that designed to store the cooking ingredients before it drop into the cooking pot. Figure 3.1 shows the example of ABS material

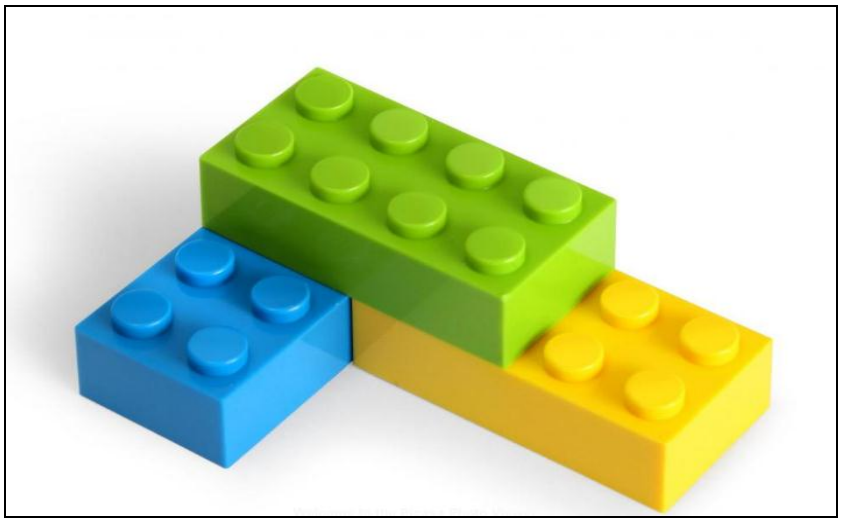


Figure 3.1 ABS material

3.2 Project Overview

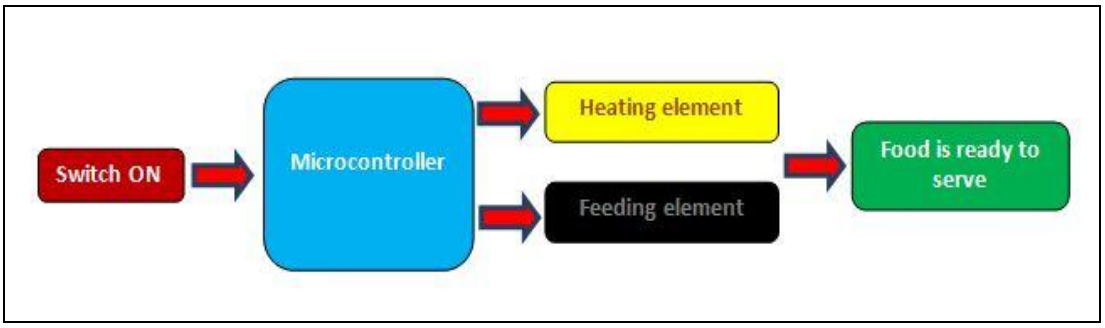


Figure 3.2 Project block diagram

Figure 3.2 shows the basic block diagram of the overall system of this project. The ingredients are placed first in the feeding compartment before the switch is ON. The project comes along with the toggle switch that works as switch that control all the operation of the system. When toggle switch is on, the microcontroller will ON and starts operates and decide which cooking process needs to start first.

To control the feeding part, stepper motor is use an attached on top of the feeding compartment. The motor will rotate the cylinder inside feeding compartment and the ingredients will drop one by one into the cooking pot. The cooking pot is placed on the cooking induction below the feeding compartment. Figure 3.3 shows the arrangement of the overall system.

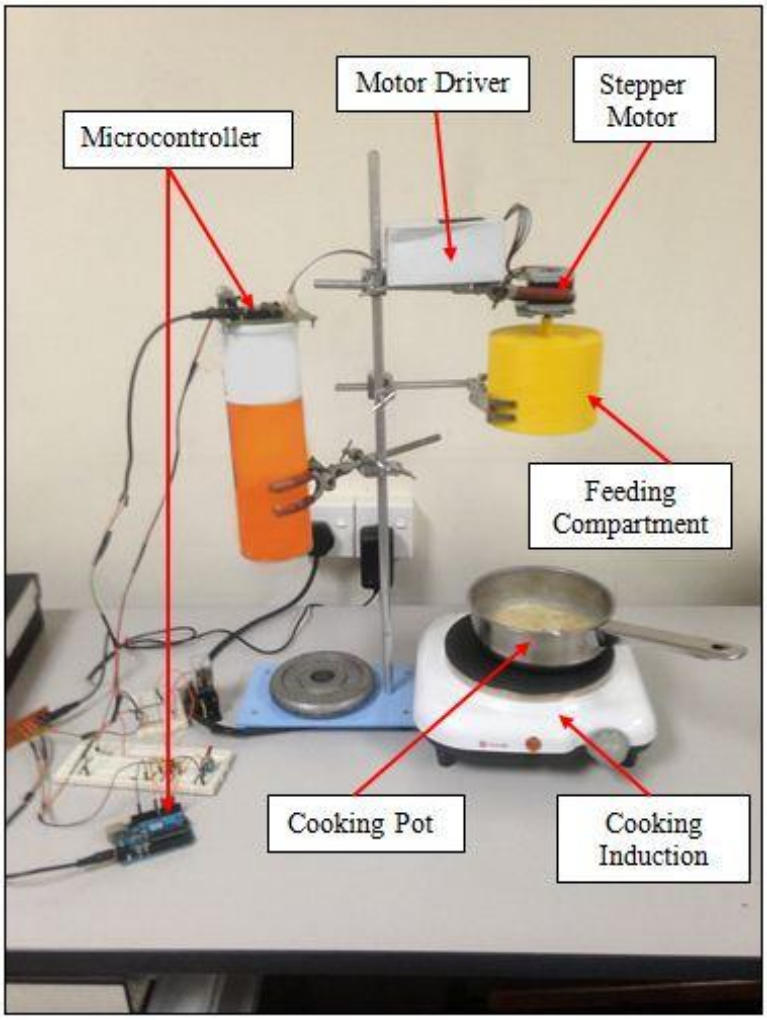


Figure 3.3 Arrangements of the cooking system

All the cooking process is controlled by the microcontroller after the switch is ON. The main important part for this project is the timing and delay of every cooking element to start it work. Figure 3.4 shows the flow chart of this project.

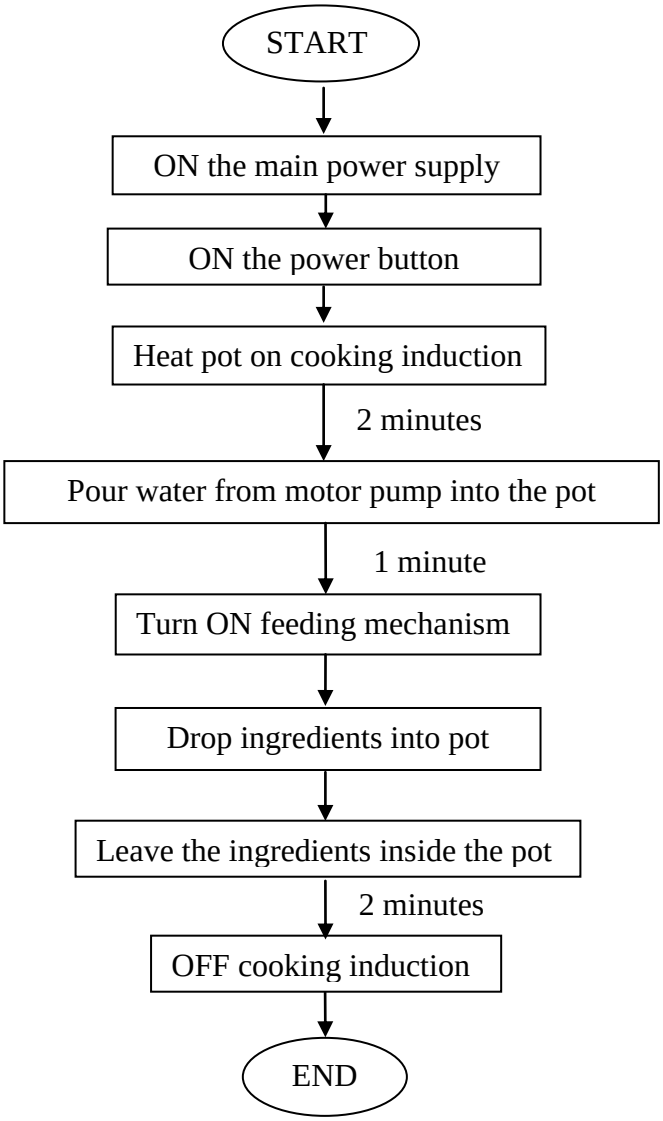


Figure 3.4: Flow chart of the system

3.3 Hardware Design

Hardware part is one of the most important parts in designing and automatic cooking machine. For this project, feeding part is needed to be designed. The design process is done by using SolidWorks2010 software [9]. It categorizes into three main

parts that is cylinder, cap, and motor external. Figure 3.3.1 shows the all three designs.

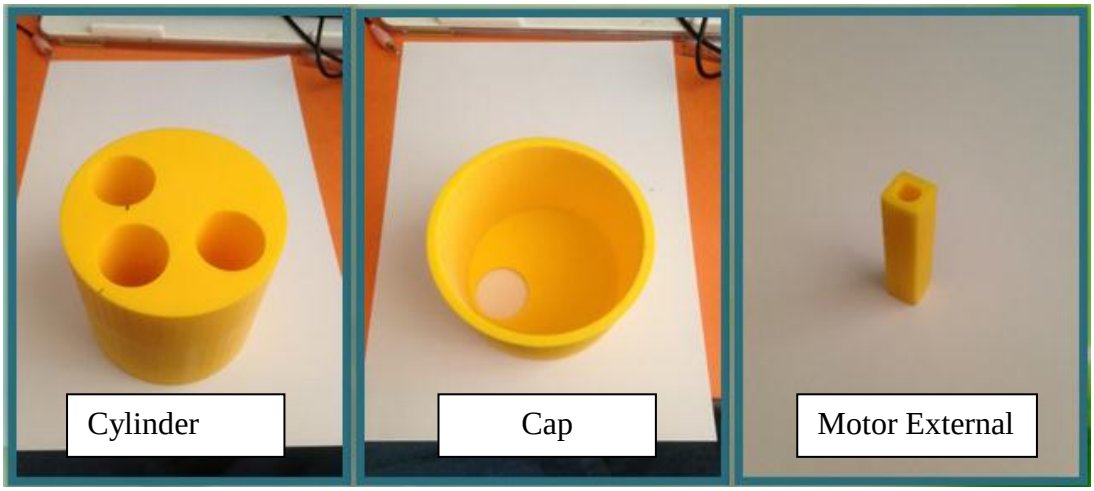


Figure 3.5: Feeding compartment

Cylinder is works as place to store the ingredients before it will drop into the cooking pot. Cap plays as a holder for the cylinder. After the ingredients is placed inside the cylinder then it will cover by the cap before inverted while the motor external is connected to the stepper motor and placed on top of the cylinder. Both cylinder and stepper motor are hold with clamp along the retort stand to make the cylinder will rotate smoothly during dropping the ingredients inside the cooking pot.

The 3D printer is used to print out all of this design. Figure 3.6 shows the 3D printer that was used.

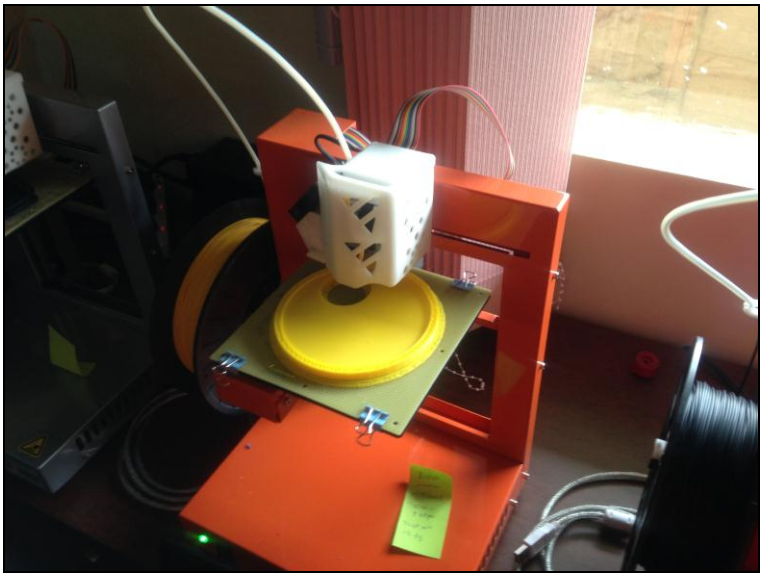


Figure 3.6: 3D Printer

3.4 Electrical Design

The electrical design and circuit connection need to modify to make sure all this cooking component will work automatically just by press a button. There are five main parts which includes stepper motor, microcontroller design, switching relay, motor pump, and power supply.

3.4.1 Stepper Motor

Stepper motor [10] is used to control the rotation of feeding compartment. Figure 3.7 shows the stepper motor used. To control the rotation of motor, first things we used motor driver to generate the motor and can easily control the type of movement. Figure 3.8 shows the motor driver used. For this project we just created four segments at the cylinder where three is used as ingredients storage and another

segment is reserved for initial state of rotation to block the ingredient from flow out through the cap.

Figure 3.7: Stepper motor

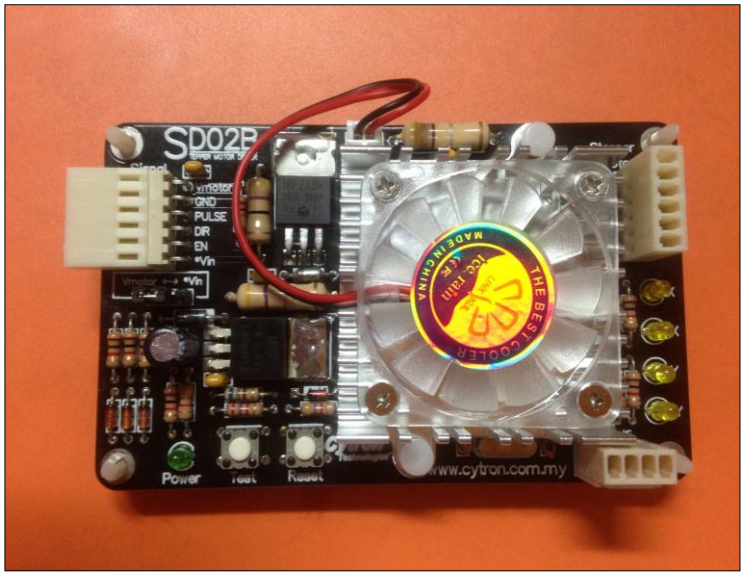


Figure 3.8: Motor driver

To control the rotation the stepper motor we use PIC16F876A [11] and ready made from Cytron Technologies. Some adjustment needs to be done so it follows the scope of this project. All the compartment need to solder to the board based on schematic given. Figure 3.9 shows the PIC16F876A before and after solder process.

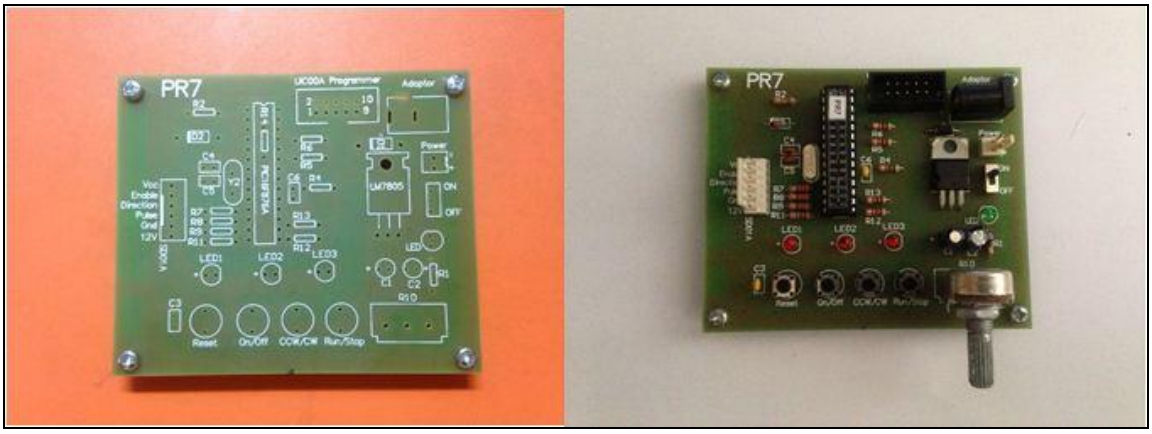


Figure 3.9: PIC16F876A circuit board

3.4.2 Microcontroller Design

Microcontroller is the main of the system. For this project we used PIC16F876A to control the stepper motor and Atmega328 that located in Arduino Uno board that will control the operation of every cooking components and the timing for each of them. The Arduino Uno board will sent the output high to every component to ON them. For this project we just used 4 output ports (Digital I/O Pins) to control the cooking induction, feeding compartment, motor pump and indicator. For this project LED is representative as the indicator. Figure 3.10 show the Arduino Uno board that was used in this project.

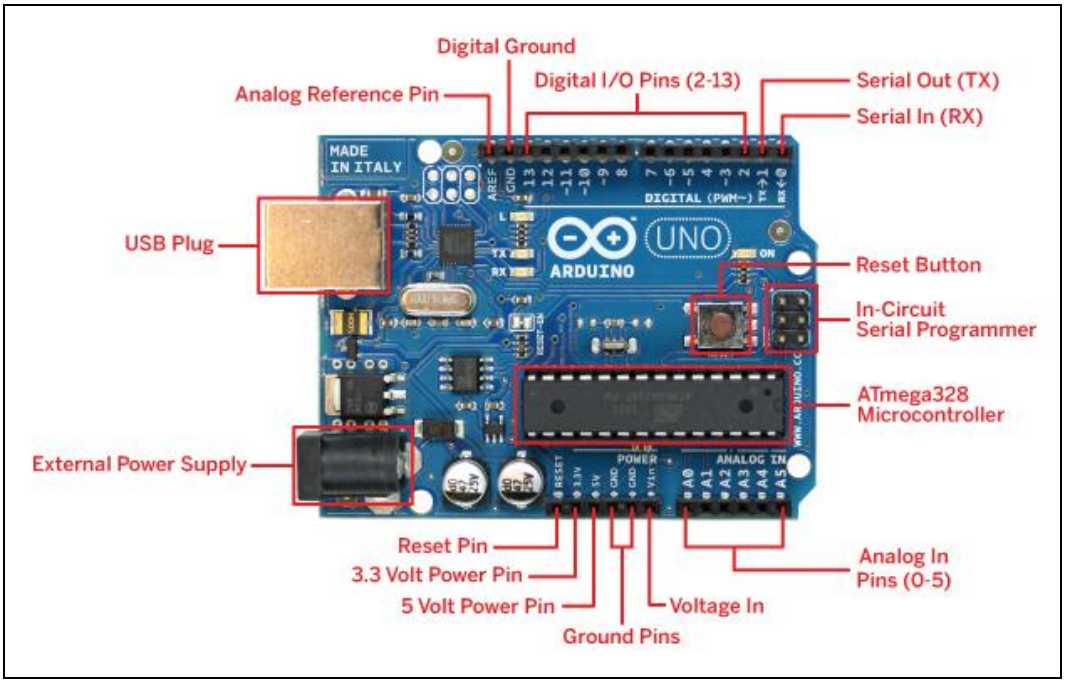


Figure 3.10: Arduino Uno board

3.4.3 Switching Relay

Relay is electronic components that will work as switch to control the current flow by using the electromechanical concept inside it. For this project, relay is used to control the ON/OFF of the cooking induction. Relay is choose based on load that it can supported. Our cooking induction is operating on 220-240V and 1500W. So 12V 10A relay [12] is choose because it can support the power 1500W. Figure 3.11 shows the relay used.

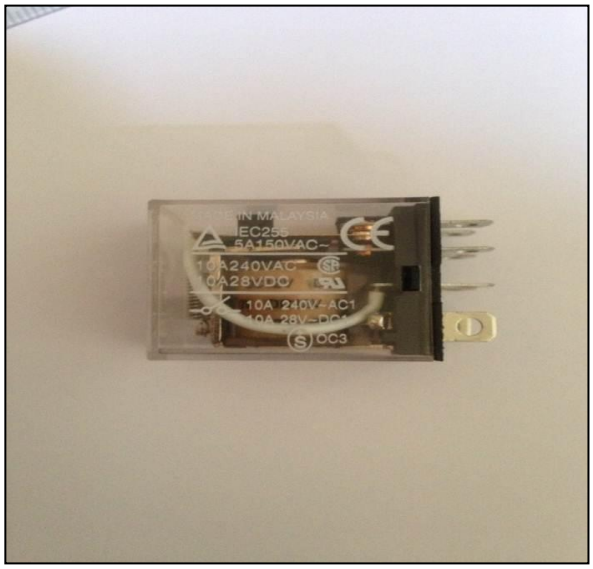


Figure 3.11: 12V 10A relay

Relay usually comes in with two types of mode of operation that is normally closed and normally opens. For this project we connected this relay to normally open pin so that the relay will work as switch when we sent output high from the Arduino. Figure 3.12 shows the circuit diagram for the relay we used. So to connect this relay with cooking induction the live wire from the cooking induction need to cut into 2 parts.

One is connected to pin 1 and another to pin 9. So when the power is ON the relay will work as normally open. Figure 3.13 shows how the relay is connected to cooking induction. To ON the relay we also need to design simple circuit so that it will turn on when output high from Arduino Uno board is sent to the relay. Figure 3.14 show the circuit that need to design for the relay. Transistor and resistor is used for the designation.

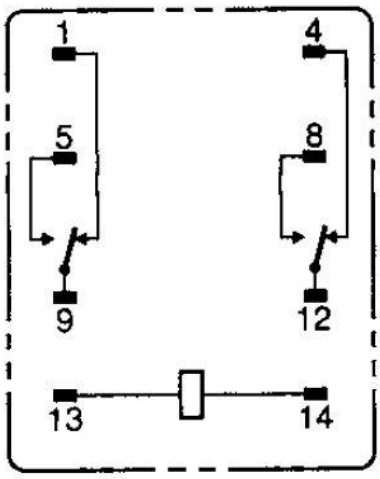


Figure 3.12: Schematic for the relay

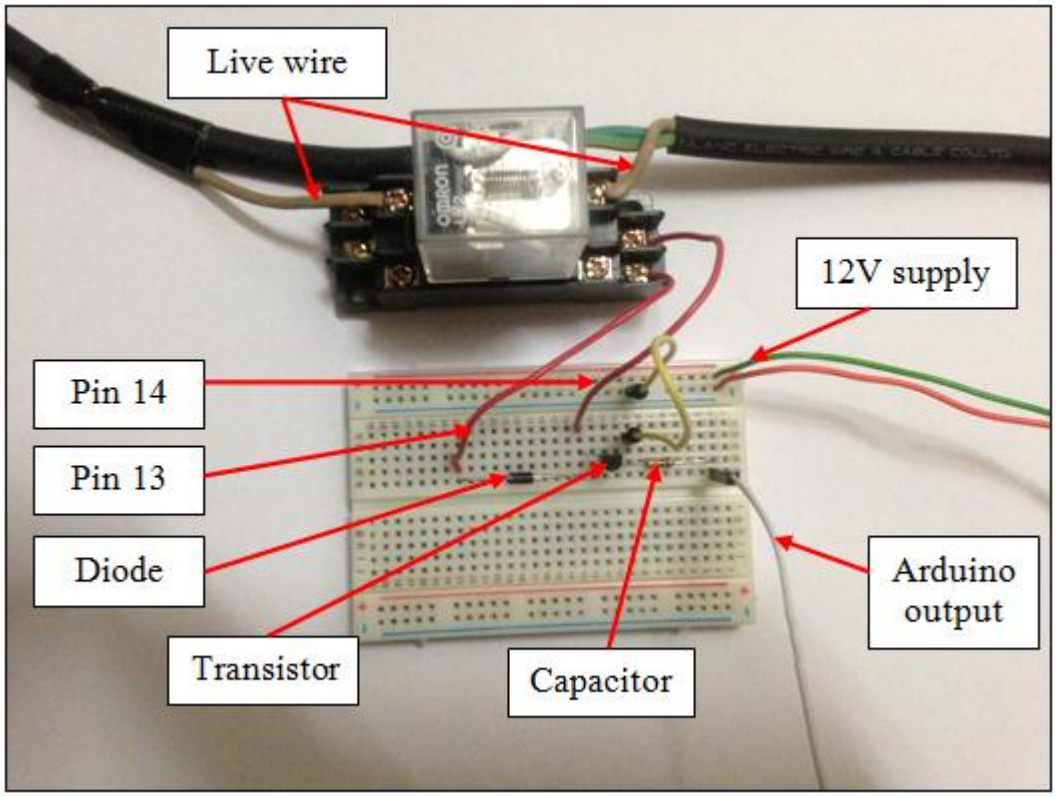


Figure 3.13: Relay connection

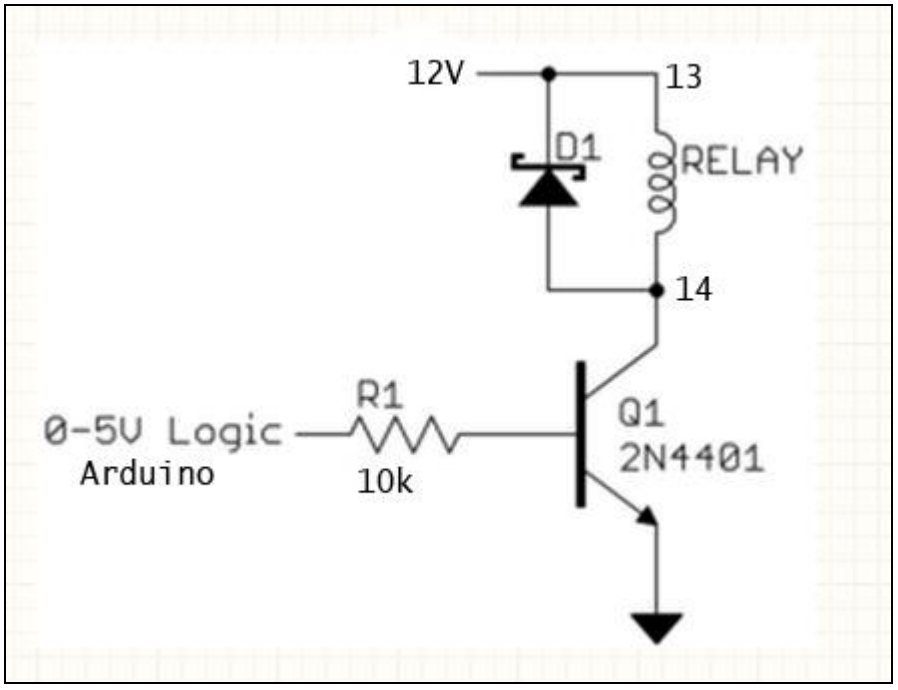


Figure 3.14: Circuit design for relay

This relay needs to supply 12*V* so that it can operate as switch. The 12*V* supply came from the adapter 12*V* 2*A*. This power supply is connected to pin 13. The diode is used and connected parallel with the coil inside the relay to prevent the "spike" occur when the current to the coil is suddenly turned off. When this happen the high current will flow through the transistor and the transistor will damage. So the diode will make sure that all the components in a good condition.

3.4.4 Motor Pump Control

A 12*V* DC motor pump is used to pump the liquid ingredient to the cooking pot. In this project water is need to send into the cooking pot automatically as boiling medium before the others ingredients is dropped. Figure 3.15 shows the 12*V* DC motor pump that used in this project.

Figure 3.15: 12*V* DC motor pump

To control the motor pump, the H-bridge L293DNE is used. Figure 3.16 shows the model of h-bridge that controls the motor pump. This h-bridge is connected with the Arduino Uno board. L293DNE can control maximum 2 motors per operation but for this project we just use a single motor pump to deliver the water into the cooking pot.

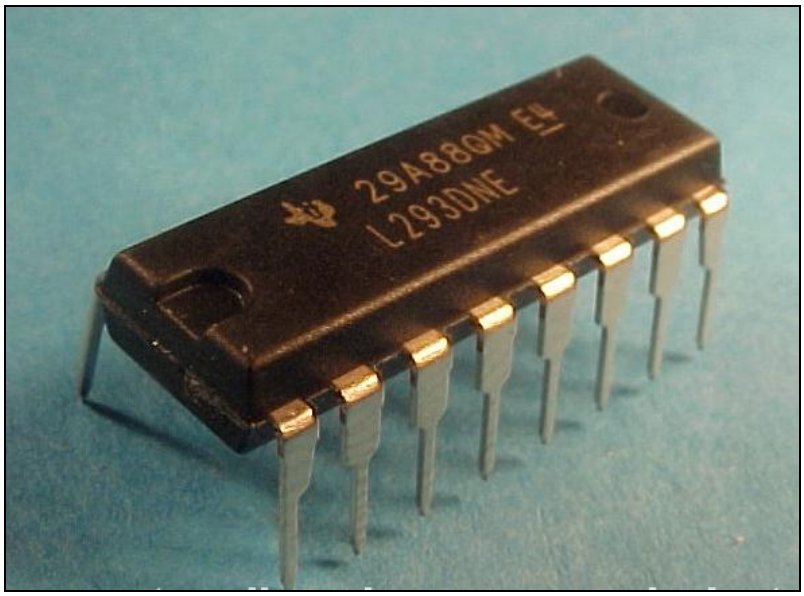


Figure 3.16: H-bridge L293DNE

Figure 3.17 shows the schematic of H-bridge L293DNE and how it is connected with the Arduino Uno board.

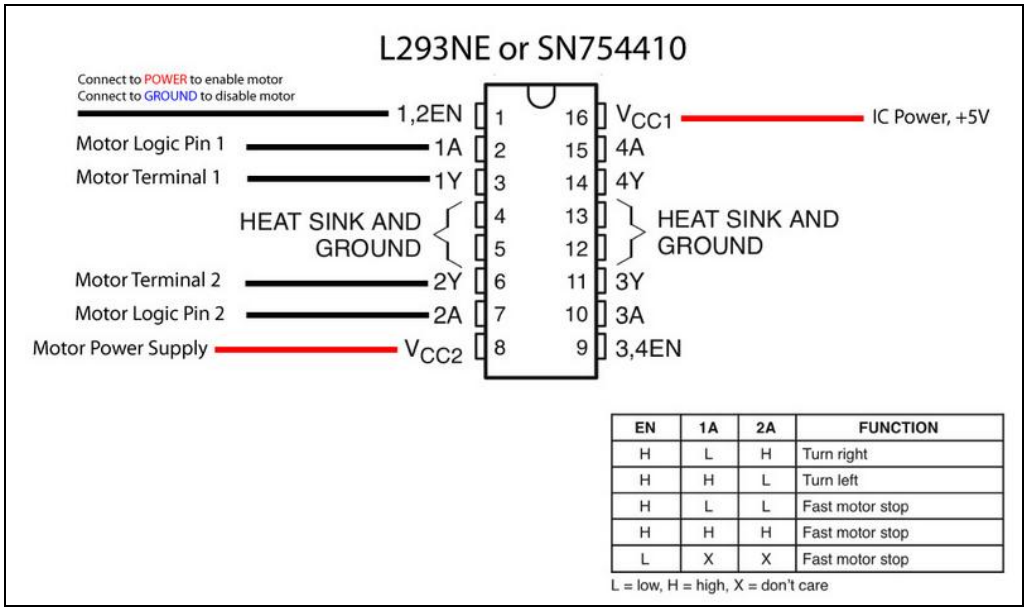


Figure 3.17: Schematic for L293DNE

Pin 3 and 4 is connected to motor pump while pin 8 and pin 16 are connected to 12*V* power supply and 5*V* Arduino Uno board voltage supply respectively. All the connection is connected on protoboard. Figure 3.18 shows the connection of L293DNE and Arduino Uno board. H-bride can control the direction of DC motor, but for this project we just prefer one direction only to send the water into the cooking pot.

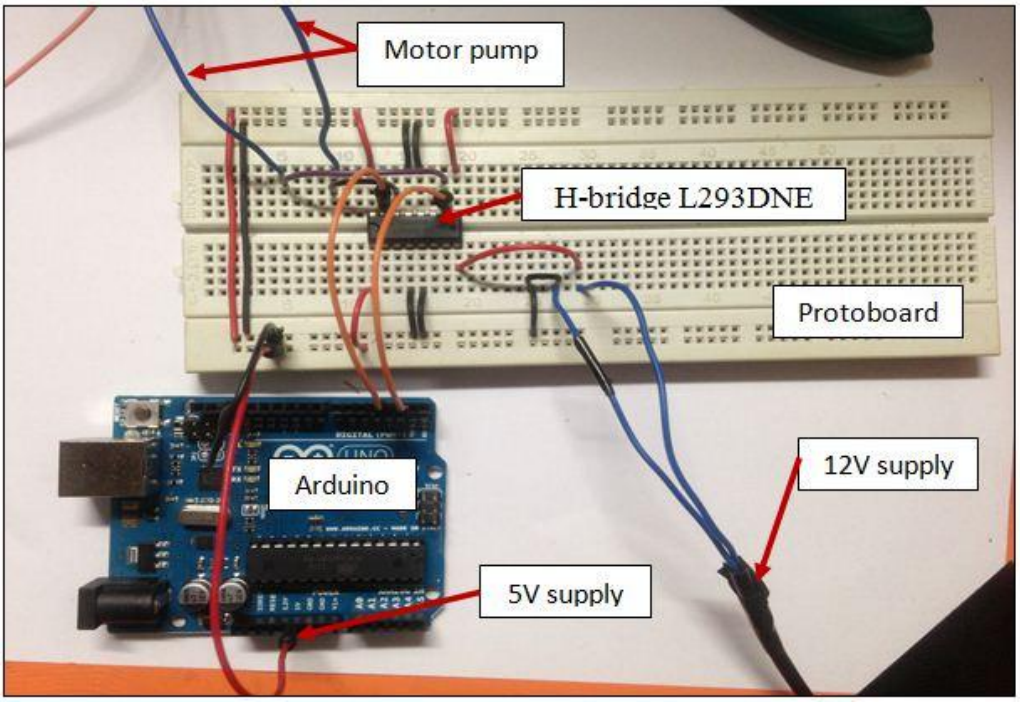


Figure 3.18: L293DNE connection

3.4.5 Power Supply

In this project, two different power supplies are used. 240*V* for the cooking induction while 12*V* 2*A* for Arduino Uno board, PIC16F876A and relay supply. Figure 3.19 show the 12*V* 2*A* adapter. To make this system more automatically and to reduce the power supply source new circuit needs to design. Simple circuit is drew on board and go for etching process. Figure 3.20 show how 12*V* 2*A* is distributed to the microcontroller and the relay.

Figure 3.19: 12V 2A AC adapter

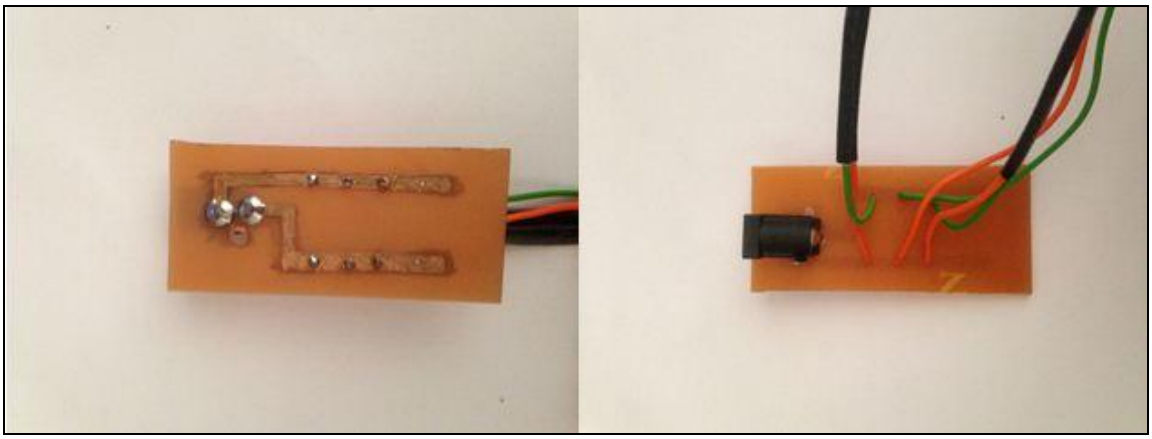


Figure 3.20: Power supply distribution

3.5 Software Development

In this project software part is one of the main part in designing an automatic cooking machine. The software we used is SolidWorks 2012, MicroC for the PIC and Arduino in constructing the design and algorithm of the project.

3.5.1 SolidWorks 2010

SolidWorks 2010 is the software that helps in designing the 3D object. With the simple manual and interface this software is easy to use. For this project SolidWorks is used to design the feeding compartment. Figure 3.21 shows the overview of the SolidWorks 2010 software

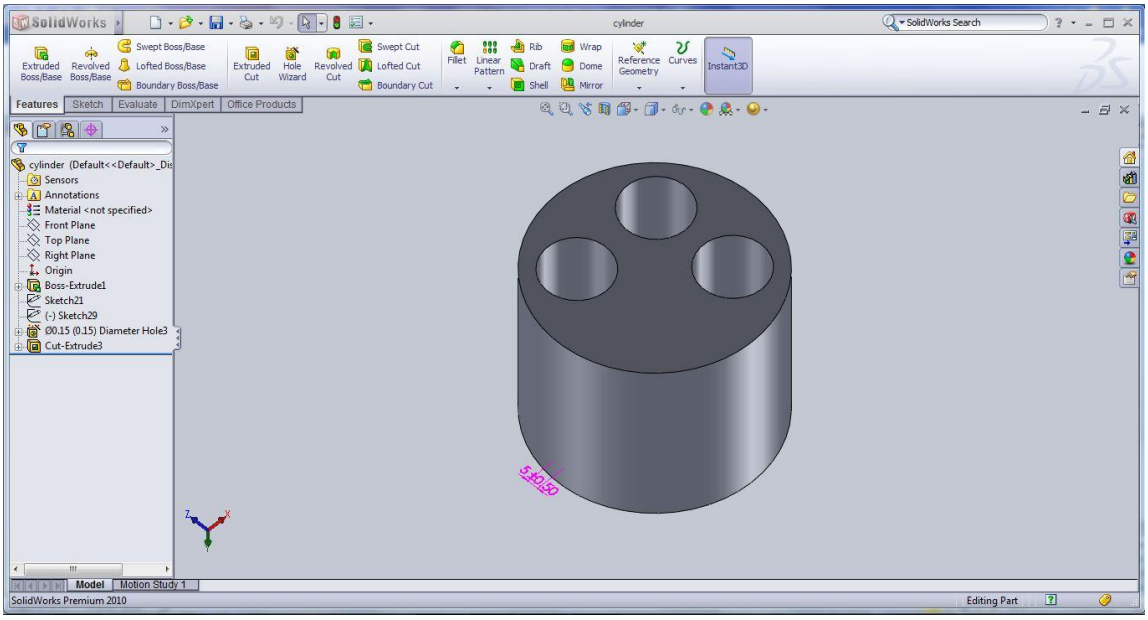


Figure 3.21: Overview of SolidWorks 2010 software

In SolidWorks 2010, to create the feeding compartment for this project, we just use basic shape as a cylinder. After finish the design, it should save in *.stl* format so we can send it for the printing process. Three main parts are designed using this software with certain measurement. Table 3.1 shows the measurement of the feeding compartment using SolidWorks 2010.

Table 3.1: Measurement for feeding part

PART	DIAMETER (*mm*)	HEIGHT (*mm*)
Cylinder	50	80
Cap	51	85
Motor external	-	40

3.5.2 MicroC for Peripheral Interface Controller (PIC)

MicroC is the software that used to write and compile the program for stepper motor in feeding part. C language [13] is used to write the command. MPLAB IDE is used as a platform for the code. Figure 3.22 shows the overview the MPLAB IDE software from MicroC.

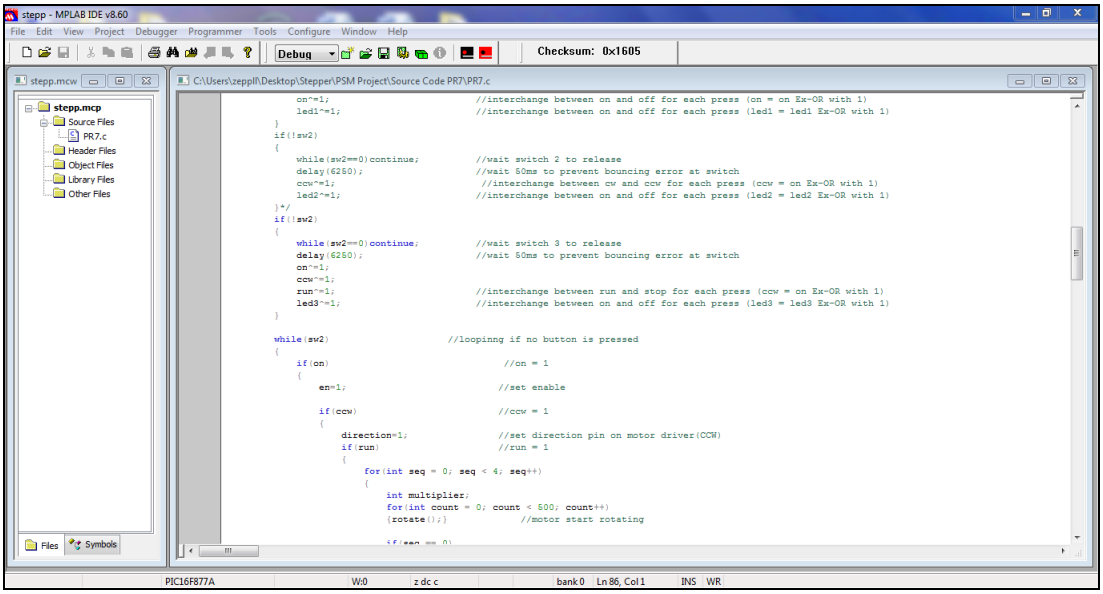

stepp - MPLAB IDE v8.60
File Edit View Project Debugger Programmer Tools Configure Window Help
Debug
Checksum: 0x1605
stepp.mcw
stepp.mcp
Source Files
PR7.c
Header Files
Object Files
Library Files
Other Files
Files
Symbols
C:\Users\zeppll\Desktop\Stepper\PSM Project\Source Code PR7\PR7.c
on^=1; //interchange between on and off for each press (on = on Ex-OR with 1)
led1^=1; //interchange between on and off for each press (led1 = led1 Ex-OR with 1)
}
if(!sw2)
{
while(sw2==0)continue; //wait switch 2 to release
delay(6250); //wait 50ms to prevent bouncing error at switch
ccw^=1; //interchange between cw and ccw for each press (ccw = on Ex-OR with 1)
led2^=1; //interchange between on and off for each press (led2 = led2 Ex-OR with 1)
}*/
if(!sw2)
{
while(sw2==0)continue; //wait switch 3 to release
delay(6250); //wait 50ms to prevent bouncing error at switch
on^=1;
ccw^=1;
run^=1; //interchange between run and stop for each press (ccw = on Ex-OR with 1)
led3^=1; //interchange between on and off for each press (led3 = led3 Ex-OR with 1)
}
while(sw2) //loopinng if no button is pressed
{
if(on) //on = 1
{
en=1; //set enable
if(ccw) //ccw = 1
{
direction=1; //set direction pin on motor driver(CCW)
if(run) //run = 1
{
for(int seq = 0; seq < 4; seq++)
{
int multiplier;
for(int count = 0; count < 500; count++)
{rotate();} //motor start rotating
PIC16F877A
W:0
z dc c
bank 0 Ln 86, Col 1
INS WR

Figure 3.22: MicroC compiler MPLAD IDE

For this project, to control the rotation the stepper motor we divided the rotation into four steps. Each step is set to rotate about 90^0 degrees and add some delay for the next turn. The delay is obtained from the experiment on types of food we use to cook. For this project we use soup-based dishes as a food sample. Figure 3.23 shows how the coding to set the rotation of stepper motor.

```
while(sw2)                          //loopinng if no button is pressed
{
 if(on)                             //on = 1
 {
  en=1;                             //set enable
  if(ccw)                           //ccw = 1
  {
   direction=1;                     //set direction pin on motor driver(CCW)
   if(run)                          //run = 1
   {
    for(int seq = 0; seq < 4; seq++)
    {
     int multiplier;
     for(int count = 0; count < 500; count++)
     {rotate();}                                    //motor start rotating

     if(seq == 0)
     {  multiplier = 30;}       // Delay for 30 seconds

     if(seq == 1)
     {  multiplier = 30;}       // Delay for 30 seconds

     if(seq == 2)
     {  multiplier = 10;}       // Delay for 10 seconds

     if(seq == 3)
     {  multiplier = 2;}        // Delay for 2 seconds

     for(;multiplier>0;multiplier--)
     {delay(125000);}
    }
```

Figure 3.23: Code to control the rotation of stepper motor

After finish the compiler than the code is burn into the PIC chip using UIC00B USB ICSP PIC Programmer [14]. The PIC is used just to control the rotation of the stepper motor in feeding compartment while the rest of the components are controlled by the Arduino Uno board microcontroller.

3.5.3 Arduino Uno Board (Atmega328)

The Arduino Uno board [15] is types of microcontroller that easy to handle and compile the command. Basic language for this microcontroller is C language [13]. Figure 3.24 shows the overview of the Arduino compiler.

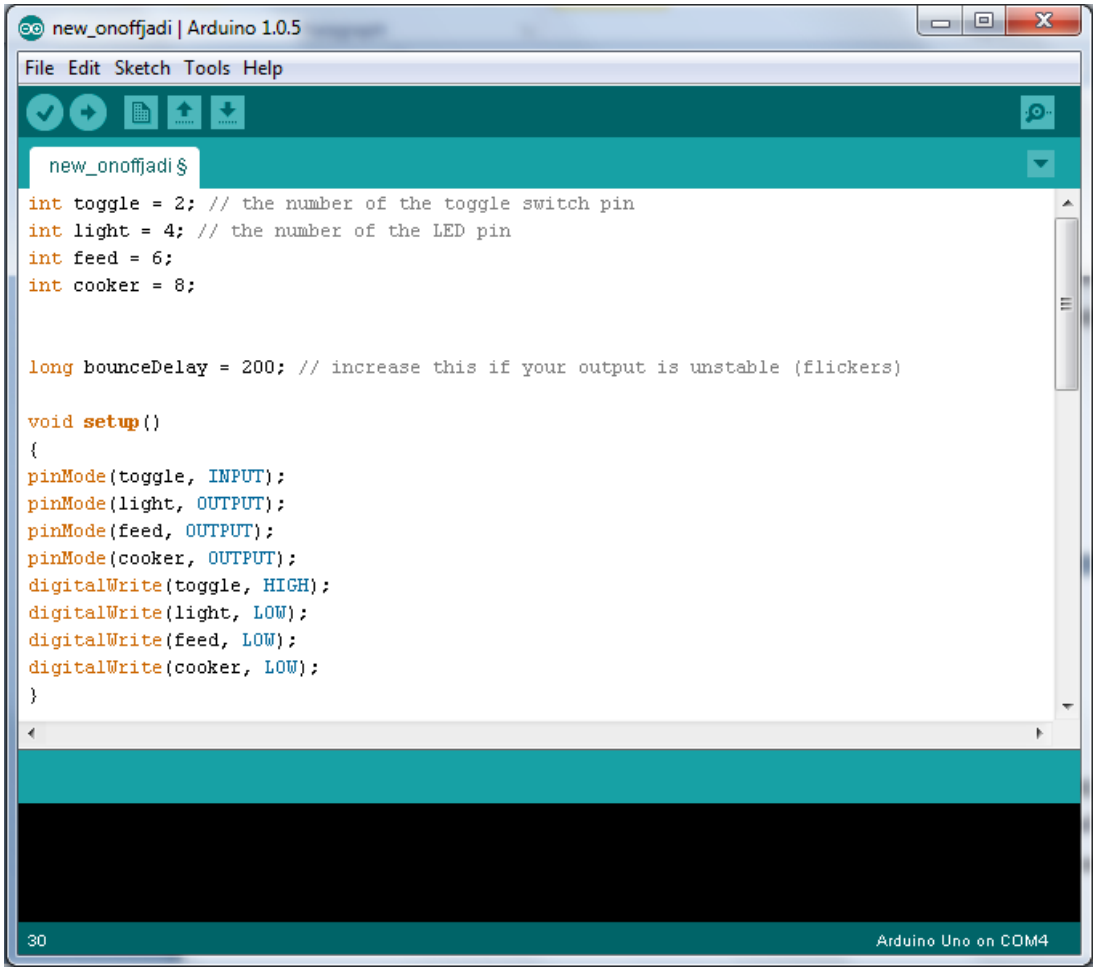


Figure 3.24: Arduino compiler interface

In this project the use of Arduino is more focus on the timing and switching the electrical components such as relay (cooking induction), stepper motor, and motor pump. Figure 3.25 shows how the Arduino is connected to the electrical components.

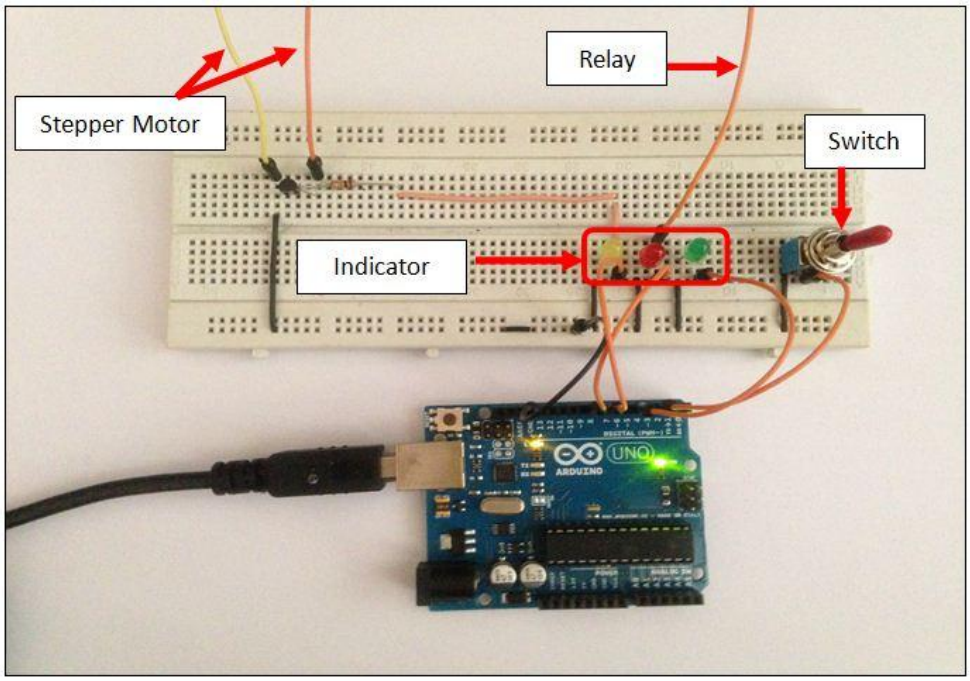


Figure 3.25: Connection of Arduino Uno board

The LED in the circuit represents the indicator in this project. The green LED will light when the switch is ON. The red LED will light up and connected to the relay at the cooking induction while the yellow LED is for feeding part. When the yellow LED light up then stepper motor will start to rotate. The ON/OFF the LED shows the current operation cooking components.

The timing to ON/OFF the cooking components is decided based on the experiment how the components should ON or OFF to finish a complete dish. Figure 3.26 shows the coding for Arduino to set the timer for each of the cooking components.

```
if (digitalRead(toggle) == HIGH )
{
  delay(bounceDelay);
  if( digitalRead(toggle) == HIGH )
  {
    digitalWrite(light, HIGH);          // on the green LED as indicator
    delay(1000);
    digitalWrite(cooker, HIGH);         // start ON the cooking induction
    delay(120000);                      // delay for 2 minutes
    digitalWrite(feed, HIGH);           // stepper motor start to rotate
    delay(60000);                       // delay for 1 minutes
    digitalWrite(feed, LOW);            // turn OFF the stepper mototr
    delay(2000);
    digitalWrite(cooker, LOW);          // turn OFF cooking induction
    while(digitalRead(toggle) == HIGH)
    {
    }
   }
}
else
{

 digitalWrite(light, LOW);
 digitalWrite(cooker, LOW);
 digitalWrite(feed, LOW);
}
}
```

Figure 3.26: Timing for cooking component

In the Arduino to set the 1 second for the delay we just put 1000 on the delay command.

CHAPTER 4

RESULTS AND DISCUSSION

This chapter discusses on the results obtained from the experiments and solutions on problems faced during the progression of this project.

4.1 Feeding Mechanism

The feeding mechanism in this project is designed to be a rotating type. Figure 4.1 shows the installation of the feeding cylinder. The cylinder has 3 compartments to store the cooking ingredients. It is fixed to a ‘cap’, which is a hollow cylinder, with one of its end closed. The closed end has a hole to allow the cooking ingredients to drop. The stepper motor is connected at the top of the cylinder where special square hole is built.

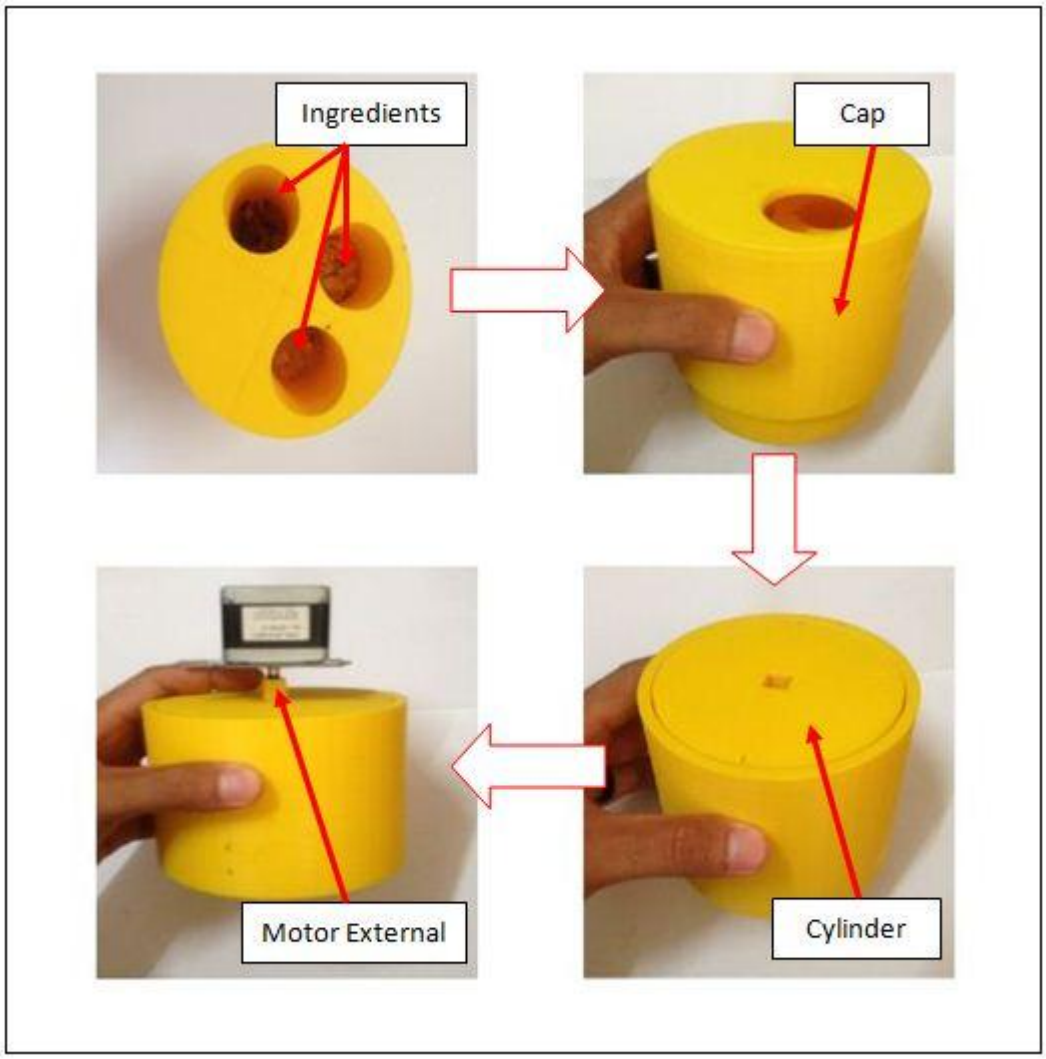


Figure 4.1: Feeding compartment installation

In this project, a soup-based dish is used to test the operation of the automatic cooking machine. Three ingredients were loaded into the feeding compartments which are the soup paste, minced chicken and fried onion. The hole on the 'cap' is set to meet the flat surface of feeding cylinder. The motor will rotate the 'cap', which automatically rotates the position of the hole, which allows cooking ingredients to drop through the hole.

4.2 Cooking Process

The automatic cooking machine was tested using a soup-based dish. The Figure 4.2 shows the full set-up of the automatic cooking machine. The first step is to boil the water inside the cooking pot. Time taken to boil the water depends on the thickness of the cooking pot. In this project thin cooking pot (as shown in Figure 4.3) was used to save the boiling time. And reduce the waiting time for the soup to cook.

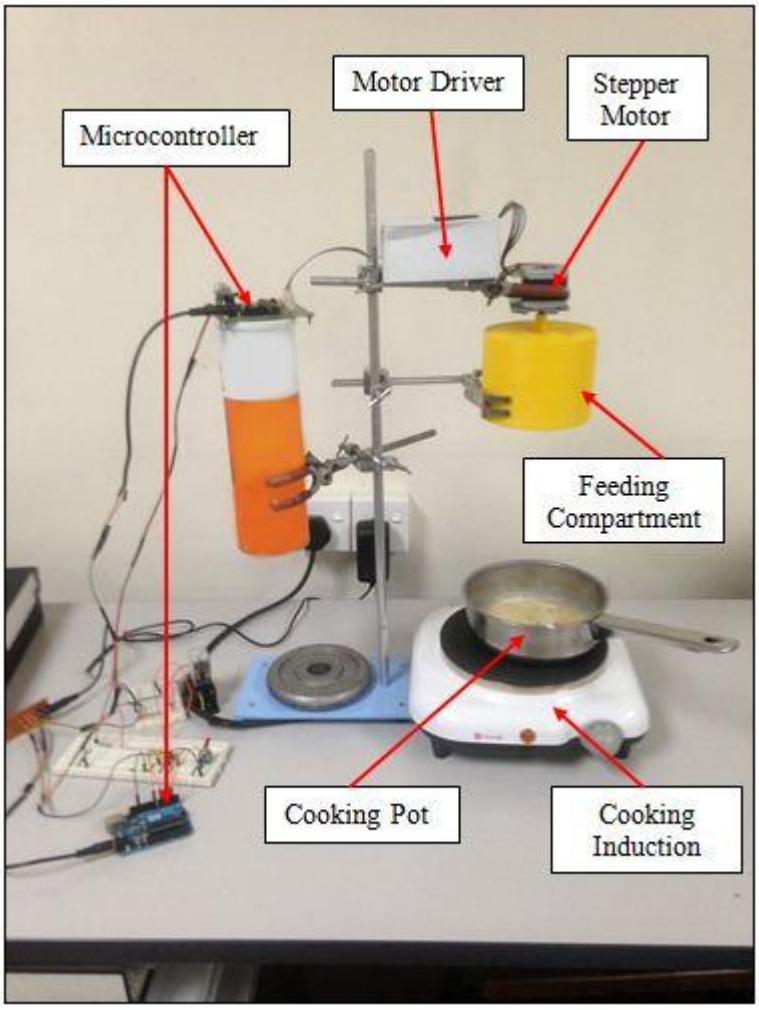


Figure 4.2: Full set-up of the cooking system

Figure 4.3: Cooking pot

The time taken for water to boil was recorded. Once the water is boiled, the feeding compartment will be automatically ON. The motor will start rotating and causes the hole on the hollow cylinder to move its position to the first compartment and start dropping the soup paste. After 30 seconds, the motor will rotate and minced chicken is dropped and follow by the fry onion after next 30 seconds. Several experiments and observation were conducted to record the time taken to drop each ingredients of feeding compartment

Table 4.1 shows the results of the time taken for each cooking sequence obtained for the soup to complete cooked. The result is recorded based on time needed to start the operation of each process.

Table 4.1: Result for the soup to complete cooked

NO	COOKING PROCESS	TIME
1	Pre-heat water until its boiled	2 minutes
2	Drop the soup pastes	30 seconds
3	Drop the minced chicken	30 seconds
4	Wait the soup to cook	30 seconds
5	Drop the fried onions	10 seconds
6	Off the cooking induction	After 3 minutes

The automatic cooking machine took 4 minutes to complete a simple soup-based dish. The time may vary if the temperature of cooking induction is set at a different range. Figure 4.3 shows the soup that already cooked using this automatic cooking machine.

Figure 4.3: Final Output of the Automatic Cooking Machine

4.3 Cost of the Project

Table 4.2 shows the cost of the overall project. The total cost of this project is RM550.00

Table 4.2: Cost of overall project

NO	ITEMS	PRICE
1	Controlling stepper motor	RM230.00
2	Cooking Induction	RM90.00
3	Arduino board	RM75.00
4	Adapter 12V 2A	RM20.00
5	USB IC SP PIC Programmer	RM50.00
6	USB Cable	RM5.00
7	Food Sample	RM30.00
8	Wire and Connector	RM50.00
		=RM550.00

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

This chapter concludes the whole project and proposes some improvements for future advancement to enhance the application of this project

5.1 Conclusion

The development of an automatic cooking machine can be done by combination of several basic cooking equipments. In this project soup-based dishes is choose as food sample. Starting with the pre-heat the cooking induction until all the ingredients are dropped into the cooking pot are controlled by the Arduino Uno microcontroller.

There are several methods that can be used in feeding part to deliver the ingredients into the cooking pot such as using a conveyer and just using a stepper motor. Using a conveyer is more practical than using a motor because it can store or placed a lot of ingredient on it before its ready to send into the cooking pot. In this

project stepper motor is used to reduce the cost and it's suitable with the design of feeding compartment in this automatic cooking machine.

The timing of each components are varies depend on the ingredients used. Several experiments are done to get the correct timing for the dish to cook. Starting with the time taken for the water to boil inside the cooking pot, ingredient dropping and last but not list the time require for the dish to complete cooked.

The overall time taken to complete soup-based dish in this project is about 4 minutes before the user can take out the soup from the cooking pot. In conclusion, the project is successfully implemented and the objectives of the project are achieved to design an automatic cooking machine with just press a button.

5.2 Recommendations

To make this project more marketable in the future, some improvement and adjustment are required on this project. To cook different types of food usually need a lot of ingredients that need to prepare. So to overcome this problem, the feeding parts need to justify and increase its size and the number of ingredient's compartment.

Next, to improve the quality of cooking stirrer is need to locate inside the cooking process so that all the ingredients are perfectly cooked. Mechanical stirrer is suggested so it can be timing with the microcontroller.

REFERENCES

1. Snyder, L. (June 10, 1932). Automatic Doughnut Cooking Machine..
2. Alfio, P. (Sep. 20, 1982). Automatic Machine for Cooking Soup-Paste, Rice, Pot Herbs or Other Food-Stuffs in Water. Italy, Angelo Po Grandi Impianti S.P.A.
3. Mak, S. M. (Jul. 27, 1988). Computer Controlled, Fully Automatic, Short-order Wok Cooking System for Preparing Stir-fried Chinese Food. United State of America, Larry B. Harvey.
4. Yan, W. X., S. J. T. U. Robotics Res. Inst., Et Al. (8-10 Oct. 2006). A New Automatic Cooking Machine for Chinese Dishes Automation Science and Engineering, 2006. CASE '06. IEEE International Conference On**:** 534 – 53
5. Gongwer, N. G. D. (Jun. 12, 1984). Automatic Food Cooking Machine, Nelgo Manufacturing Corporation.
6. Maurice Tate, O. C., Fla; Robert L. Thompson; John H. Wilbur (Feb. 27, 1986). Automatic Cooking Machine. Washington, U1 Group.
7. Frederic A. Slicher, G. E. J. G., Westchester, both of lll (1972). Automatic Machine for Vending Fried Foods, Slicher, by said Gaysowski.
8. Tatsui Tsunoda, S. O., Kazuma Miyamoto, Makoto Matsumoto, Heiji Baba (Feb. 7, 1975). Automatic Cooking and Vending Machine for Boiled Noodles. Japan, Kawatetsu Metrological Equipment and Vending Machine Company, Ltd., Nishinomiya, Japan.
9. Greg Jankowski, R. D. (2008). *SolidWorks for Dummies,* Wiley Publishing, Inc.
10. Minebea Stepping Motor Data sheet. 2013, Minebea-Matsushita Motor Corporation.
11. PIC16F87XA Data Sheet. 2003, Microchip Technology Inc.

12. *General-purpose Relay Data Sheet. 2003,* Omron Corporation.
13. Gookin, D. (2004). *C For Dummies, 2nd Edition*. Canada, Wiley Publishing, Inc.
14. *UIC00B USB ICSP PIC Programmer User's Manual.* 2011, Cytron Technologies.
15. Mcroberts.M (2009). *Arduino Starters Kit Manual - A Complete Beginners Guide to the Arduino*, Earthshine Design.

APPENDIX A

SOURCE CODE FOR PIC

```
#include <pic.h>          //include header file

//        configuration
//=============================================================
=//
__CONFIG ( 0x3F32 );       //The configuration bits “0x3F32” is used to make
configure the
                  //correct setting for this PIC, 0x refers to Hexadecimal whereas
3F32 means:
                  //• Set the oscillator as high speed (HS – 4MHz to 20MHz crystal)
                  //•    Off the Watchdog Timer
                  //•    On Power On Timer
                  //•    Off Brown Out Detect
                  //•    Disable Low Voltage Program
                  //•    Off data EEPROM Read Protect
                  //•    Off Flash Program Write Protection
                  //•    Off Code Protect


//        define
//=============================================================
=//
#define sw2           RB2
#define led1          RC0
#define led2          RC1
#define led3          RC2
#define pulse         RC3
```

```
#define direction       RC4
#define en              RC5

//      function prototype
//============================================================//
void delay(unsigned long data);
void rotate(void);

//      global variable
//============================================================//
unsigned char on=0, ccw=0, run=0;




//      main function
//============================================================//
void main(void)
{
unsigned char turn=0;

TRISA=0b11111111;               //set PORTA as input
TRISB=0b11111111;               //set PORTB as input
TRISC=0B00000000;               //set PORTD as output

PORTC=0;                        //clear PORTC
ADCON1=0b00000000;              //set PORTA as analog input, left justified
ADCON0=0b01000001;              //configure AN0 as analog channel

led1 = 0;
led2 = 0;
led3 = 0;
```

```
while(1)
{

if(!sw2)
{
while(sw2==0)continue;        // wait switch 3 to release
delay(6250);                  // wait 50ms to prevent bouncing error at switch
on^=1;
ccw^=1;
run^=1;                       //interchange between run and stop for each press
(ccw = on Ex-OR with 1)
led3^=1;                      //interchange between on and off for each press
(led3 = led3 Ex-OR with 1)
}

while(sw2)                    //loopinng if no button is pressed
{
if(on)                        //on = 1
{
en=1;                         //set enable

if(ccw)                       //ccw = 1
{
direction=1;                  //set direction pin on motor
driver(CCW)
if(run)                       //run = 1
{
for(int seq = 0; seq < 4; seq++)
{
int multiplier;
for(int count = 0; count < 500; count++)
{rotate();}                   //motor start rotating
```

```
if(seq == 0)
{       multiplier = 30;}

if(seq == 1)
{       multiplier = 30;}

if(seq == 2)
{       multiplier = 10;}

if(seq == 3)
{       multiplier = 2;}

for(;multiplier>0;multiplier--)
{delay(125000);}
}
while(1)                        //forever
{}
}
else
{

pulse=0;        //run = 0
}
}
else                            //ccw = 0
{
direction=0;                    //clear direction pin on  motor driver(CW)
if(run)                         //run = 1
{
for(int seq = 0; seq < 4; seq++)
{
int multiplier;
```

```
for(int count = 0; count < 500; count++)
{
 rotate();}                    //motor start rotating

if(seq == 0)
{       multiplier = 30;}

if(seq == 1)
{       multiplier = 30;}

if(seq == 2)
{       multiplier = 10;}

if(seq == 3)
{       multiplier = 2;}

for(;multiplier>0;multiplier--)
{delay(125000);}
}
while(1)                      //forever
{}
}
else                          //run = 0
{
pulse=0;
}
}
}
else                          //on = 0
{
led1=0;                       //LED1 off
led2=0;                       //LED2 off
led3=0;                       //LED3 off
```

```
en=0;
ccw=0;
run=0;
}
}
}
}
//=========================FUNCTIONS=====================//
void delay(unsigned long data)
{
for( ;data>0;data-=1);
}
void rotate(void)
{
unsigned char i=0;

ADGO=1;                         //set ADGO to activate ADC
while(ADGO==1)continue;    //wait process of ADC complete

//-----------------------------------------------------------
// IF the max speed for motor driver = 20kHz
// and T = 1/f. Tmax = 1/10k = 50us
//
// From simulation, "delay(1);" need 40 instruction cycles
// Period for 1 instruction cycle = 1/(20W/4) = 200ns
// Period for 40 instruction cycles = 200n * 40 = 8us
// So, period for "delay(1);" also = 8us
//
// Now if we want to generate a delay of 20us
// the value that we need to put for "delay(x);" is:
//
//                  x = 20us/8us*1 = 6.25 = 6
//-----------------------------------------------------------
```

```
if(ADRESH==0)                  // stop
{
pulse=0;
}
else if((255-ADRESH)<=6)   // maximum speed ( control by potential meter )
{
i = 6;                              //read resultant ADC value from ADRESH
pulse=1;                          //set pulse pin on motor driver
delay(i);                         //delay time depend to the ADC value
pulse=0;                          //clear pulse pin on motor driver
delay(i);
}
else
{
i = 255-ADRESH;       //the higher the value of ADRESH, the faster the steps change.
pulse=1;                  //set pulse pin on motor driver
delay(i);                 //delay time depend to the ADC value
pulse=0;                  //clear pulse pin on motor driver
delay(i);
}
}
```

APPENDIX B

SOURCE CODE FOR ARDUINO

```
int toggle = 2;                 // the number of the toggle switch pin
int light = 4;                  // the number of the LED pin
int feed = 6;
int cooker = 8;


long bounceDelay = 200;         // increase this if your output is unstable (flickers)

void setup()
{
pinMode(toggle, INPUT);
pinMode(light, OUTPUT);
pinMode(feed, OUTPUT);
pinMode(cooker, OUTPUT);
digitalWrite(toggle, HIGH);
digitalWrite(light, LOW);
digitalWrite(feed, LOW);
digitalWrite(cooker, LOW);
}

void loop()
{

if (digitalRead(toggle) == HIGH )
{
delay(bounceDelay);
if( digitalRead(toggle) == HIGH )
```

```
{
digitalWrite(light, HIGH);              // on the LED as indicator
delay(1000);
digitalWrite(cooker, HIGH);             // start ON the cooking induction
delay(120000);                          // delay for 2 minutes
digitalWrite(feed, HIGH);               // stepper motor start to rotate
delay(60000);                           // delay for 1 minutes
digitalWrite(feed, LOW);                // turn OFF the stepper mototr
delay(2000);
digitalWrite(cooker, LOW);              // turn OFF cooking induction
while(digitalRead(toggle) == HIGH)
{
}
}
}
else
{

digitalWrite(light, LOW);
digitalWrite(cooker, LOW);
digitalWrite(feed, LOW);
}
}
```

APPENDIX C

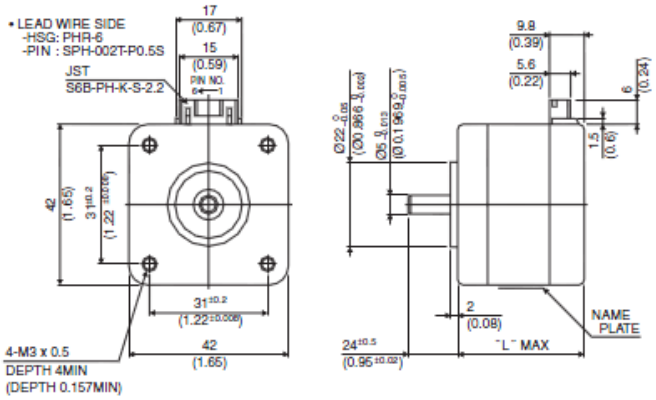
STEPPER MOTOR DATASHEET

NMB-MAT
Minebea-Matsushita Motor Corporation
eMINEBEA.COM

17PM-J 1.8°

Hybrid

■ 外観図 Outline



UNIT: mm (inch)

	"L"
17PM-J7**	26 (1.02)
17PM-J2**	30 (1.18)
17PM-J0**	34 (1.34)
17PM-J3**	38 (1.50)
17PM-J1**	42 (1.65)
17PM-J4**	48 (1.89)

結線表 PIN NO. VS PHASE

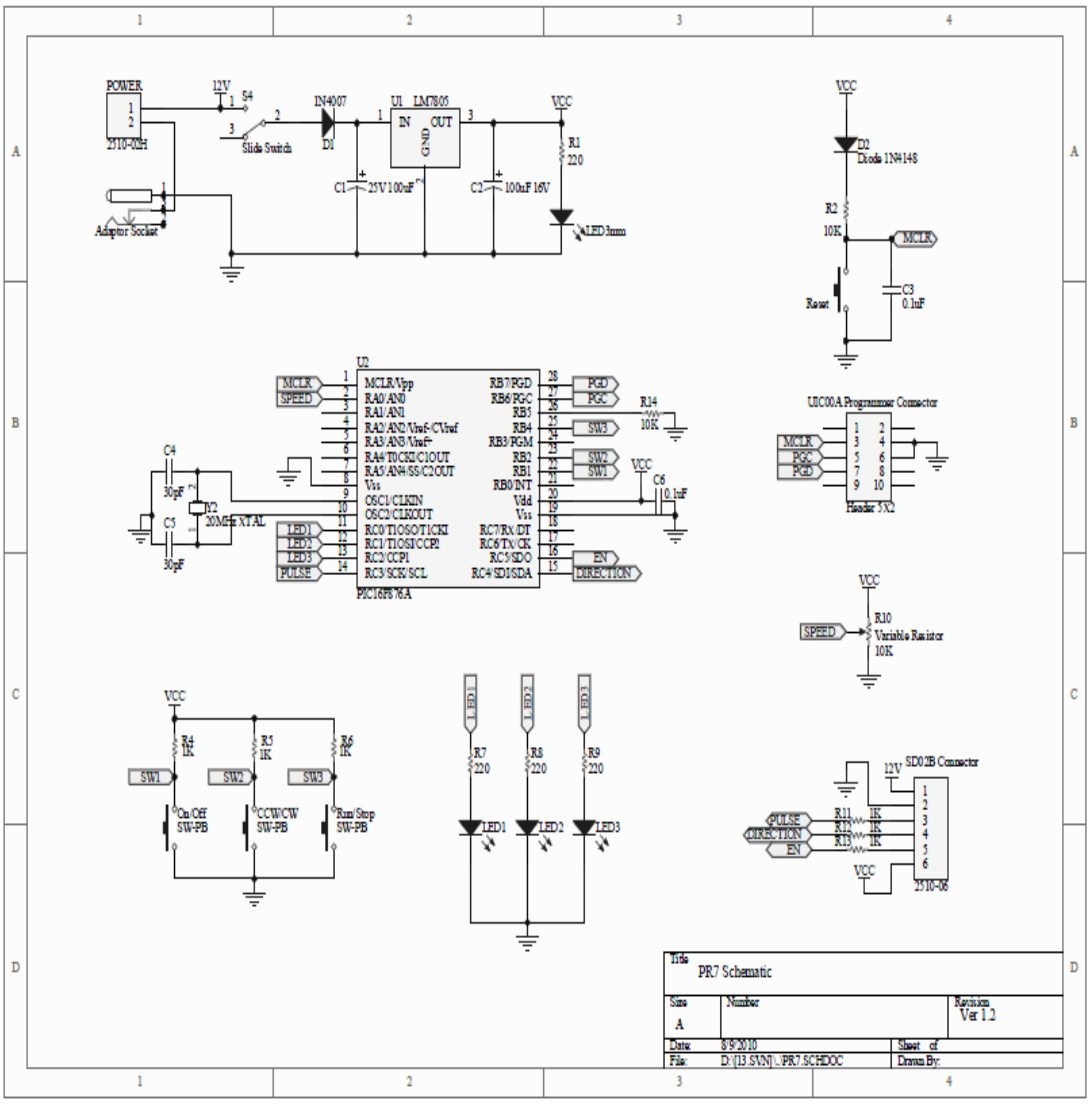
相 (PHASE)	A	A COM	$\bar{A}$	B	B COM	$\bar{B}$
ピン番号 (PIN NO.)	4	5	6	3	2	1

■ 仕様 Specifications

型式	ステップ角	ドライブ方式	定格電流	巻線抵抗	ホールディングトルク	インダクタンス	ロータイナーシャ	ディテントトルク	質量
Model	Step Angle	Drive Sequence	Rated Current	Resistance	Holding Torque	Inductance	Rotor Inertia	Detent Torque	Mass
	(deg)		(A)	(Ohms)	(mNm)	(mH)	(g·cm²)	(mNm)	(g)
17PM-J049U	1.8	UNI-POLAR	1	3.1	160	3.3	26	9.8	200
17PM-J064U	1.8	UNI-POLAR	0.6	8.3	160	8.2	26	9.8	200
17PM-J142U	1.8	UNI-POLAR	1.4	2.3	250	3.1	44	8.3	300
17PM-J149U	1.8	UNI-POLAR	1	4.3	250	5.9	44	8.3	300
17PM-J249U	1.8	UNI-POLAR	0.8	2.7	85	2.6	17	3.9	180
17PM-J264U	1.8	UNI-POLAR	0.6	6.9	85	6.7	17	3.9	180
17PM-J342U	1.8	UNI-POLAR	1.4	2.0	210	2.4	35	7.9	250
17PM-J349U	1.8	UNI-POLAR	1	3.6	210	4.7	35	7.9	250
17PM-J442U	1.8	UNI-POLAR	1.4	2.8	320	3.3	54	14.7	350
17PM-J449U	1.8	UNI-POLAR	1	4.9	320	6.3	54	14.7	350
17PM-J749U	1.8	UNI-POLAR	0.9	2.2	35	1.4	8	2.8	150
17PM-J764U	1.8	UNI-POLAR	0.6	5.6	35	0.9	8	2.8	150
17PM-J049B	1.8	BI-POLAR	0.7	6.2	205	13.0	26	9.8	200
17PM-J142B	1.8	BI-POLAR	1	4.6	320	12.5	44	8.3	300
17PM-J249B	1.8	BI-POLAR	0.6	5.4	120	10.4	17	3.9	180
17PM-J342B	1.8	BI-POLAR	0.9	4.0	260	9.7	35	7.9	250
17PM-J442B	1.8	BI-POLAR	0.9	5.6	390	13.2	54	14.7	350
17PM-J749B	1.8	BI-POLAR	0.6	4.4	53	5.8	8	2.8	150

APPENDIX D

PIC16F876A DATASHEET



APPENDIX E

RELAY DATA SHEET

Ordering Information

■ RELAYS

Standard Coil Polarity

Type	Contact form	Model		
		Plug-in socket/Solder terminals		
		Standard with LED indicator	With LED indicator and test button	Without LED indicator
Standard	DPDT	**MY2N**	**MY2IN**	**MY2**
	4PDT	**MY4N**	**MY4IN**	**MY4**
	4PDT (bifurcated)	**MY4ZN**	**MY4ZIN**	**MY4Z**
With built-in diode (DC only)	DPDT	**MY2N-D2**	**MY2IN-D2**	—
	4PDT	**MY4N-D2**	**MY4IN-D2**	—
	4PDT (bifurcated)	**MY4ZN-D2**	**MY4ZIN-D2**	—
With built-in CR (220/240 VAC, 110/120 VAC only)	DPDT	**MY2N-CR**	**MY2IN-CR**	—
	4PDT	**MY4N-CR**	**MY4IN-CR**	—
	4PDT (bifurcated)	**MY4ZN-CR**	**MY4ZIN-CR**	—

Note: 1. When ordering, add the rated coil voltage to the model number. Rated coil voltages are given in the coil ratings table.
Example: MY2 AC6(S)
↑
Rated coil voltage

2. Arc barrier standard on all four-pole relays.
3. Other models also available, such as, three-pole versions, flangemount, PCB, etc. Contact your Omron Representative for details.

OMRON

Ordering Information - continued from previous page

Reverse Coil Polarity

Type	Contact form	Model	
		Plug-in socket/Solder terminals	
		With LED indicator	With LED indicator and test button
Standard (DC only)	DPDT	**MY2N1**	**MY2IN1**
	4PDT	**MY4N1**	**MY4IN1**
	4PDT (bifurcated)	**MY4ZN1**	**MY4ZIN1**
With built-in diode (DC only)	DPDT	**MY2N1-D2**	**MY2IN1-D2**
	4PDT	**MY4N1-D2**	**MY4IN1-D2**
	4PDT (bifurcated)	**MY4ZN1-D2**	**MY4ZIN1-D2**

Note: 1. When ordering, add the rated coil voltage to the model number. Rated coil voltages are given in the coil ratings table.
Example: MY2 AC6(S)
↑
Rated coil voltage

2. Arc barrier standard on all four-pole relays.

Specifications

■ COIL RATINGS

Rated voltage		Rated current		Coil resistance	Inductance (reference value)		Must operate	Must release	Max. voltage	Power consumption (approx.)
		50 Hz	60 Hz		Arm. OFF	Arm. ON	% of rated voltage			
AC	6 V*	214.1 mA	183 mA	12.2 Ω	0.04 H	0.08 H	80% max.	30% min.	110%	1.0 to 1.2 VA (60 Hz)
	12 V	106.5 mA	91 mA	46 Ω	0.17 H	0.33 H				
	24 V	53.8 mA	46 mA	180 Ω	0.69 H	1.30 H				
	48 V*	25.7 mA	22 mA	788 Ω	3.22 H	5.66 H				
	110/120 V	9.9/10.8 mA	8.4/9.2 mA	4,430 Ω	19.20 H	32.1 H				0.9 to 1.1 VA (60 Hz)
	220/240 V	4.8/5.3 mA	4.2/4.6 mA	18,790 Ω	83.50 H	136.4 H				
DC	6 V*	151 mA		39.8 Ω	0.17 H	0.33 H		10% min.		0.9 W
	12 V	75 mA		160 Ω	0.73 H	1.37 H				
	24 V	37.7 mA		636 Ω	3.20 H	5.72 H				
	48 V*	18.8 mA		2,560 Ω	10.60 H	21.0 H				
	100/110 V	9.0/9.9 mA		11,100 Ω	45.60 H	86.2 H				

Note: 1. The rated current and coil resistance are measured at a coil temperature of 23°C with tolerances of +15%/−20% for rated currents and ±15% for DC coil resistance.
2. Performance characteristic data are measured at a coil temperature of 23°C.
3. AC coil resistance and impedance are provided as reference values (at 60 Hz).
4. Power consumption drop was measured for the above data. When driving transistors, check leakage current and connect a bleeder resistor if required.
5. Rated voltage denoted by "*" will be manufactured upon request. Ask your OMRON representative.

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■ CONTACT RATINGS

Item	2-pole		4-pole		4-pole (bifurcated)	
	Resistive load (cosφ = 1)	Inductive load (cosφ = 0.4, L/R = 7 ms)	Resistive load (cosφ = 1)	Inductive load (cosφ = 0.4, L/R = 7 ms)	Resistive load (cosφ = 1)	Inductive load (cosφ = 0.4, L/R = 7 ms)
Rated load	5A, 250 VAC 5A, 30 VDC	2A, 250 VAC 2 A, 30 VDC	3 A, 250 VAC 3 A, 30 VDC	0.8 A, 250 VAC 1.5 A, 30 VDC	3 A, 250 VAC 3 A, 30 VDC	0.8 A, 250 VAC 1.5 A, 30 VDC
Carry current	10 A (See Note.)		5 A (See Note.)			
Max. switching voltage	250 VAC 125 VDC		250 VAC 125 VDC			
Max. switching current	10 A		5 A			
Max. switching capacity	2,500 VA 300 W	1,250 VA 300 W	1,250 VA 150 W	500 VA 150 W	1,250 VA 150 W	500 VA 150 W

Note: Do not exceed the carry current of a Socket in use.

■ CHARACTERISTICS

Contact resistance		100 mΩ max.
Operate time		20 ms max.
Release time		20 ms max.
Max. operating frequency	Mechanical	18,000 operations/hr
	Electrical	1,800 operations/hr (under rated load)
Insulation resistance		1,000 MΩ min. (at 500 VDC)
Dielectric withstand voltage		2,000 VAC, 50/60 Hz for 1.0 min (1,000 VAC between contacts of same polarity)
Vibration resistance		Destruction: 10 to 55 Hz, 1.0 mm double amplitude Malfunction: 10 to 55 Hz, 1.0 mm double amplitude
Shock resistance		Destruction: 1,000 m/s^2 (approx. 100G) Malfunction: 200 m/s^2 (approx. 20G)
Life expectancy		See the following table.
Ambient temperature	Operating	−55°C to 70°C (−67°F to 158°F) with no icing (See Note.)
Ambient humidity	Operating	35% to 85%
Weight		Approx. 35 g

Note: The values given above are initial values.